THE ENGINEERING JOURNAL

Volume 42

January—December, 1959

Published by

THE ENGINEERING INSTITUTE OF CANADA

2050 Mansfield St.,

Montreal, Canada

THE ENGINEERING JOURNAL

Published monthly by

THE ENGINEERING INSTITUTE
OF CANADA
2050 Mansfield Street, Montreal

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."

THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: K. F. Tupper, M.E.I.C. — Treasurer: T. W. Eadie, M.E.I.C. — General Secretary: Garnet T. Page, M.E.I.C.

JANUARY 1959

vol. 42 no. 1

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

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Indexed in The Engineering Index

(20,650 copies of this issue printed)

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Prof. Dolphin graduated from the University of British Columbia in 1937 with a B.A.Sc. degree in civil engineering.

Until the beginning of World War II he was employed by the Hydrographic Service. During the war, he served the R.C.A.F. as a works officer and later as navigator. He returned to Canada in 1946 and was appointed lecturer at the University of Manitoba. Upon obtaining a M.Sc. degree from the University of Minnesota in 1948, he was named assistant professor of civil engineering at the University of Manitoba. In 1952 he joined the staff of the Royal Military College in his present position.

Robert F. Legget, M.E.I.C., Director, Division of Building Research, National Research Council of Canada, Ottawa. *(The Cost of Housing).*

Born in Liverpool, England, Mr. Legget graduated from the University of Liverpool in 1925 and received the degree of master of engineering from the same institution in 1927.

On his arrival in Canada in 1929, he joined the Power Corporation of Canada. He was engaged in heavy construction engineering until 1936, when he entered the educational field. After remaining on the staff of Queen's University for two years, he transferred his services to the University of Toronto, where he was successively assistant professor, then associate professor and consultant on soil and foundation problems. In 1947 he was appointed by the National Research Council to head the new Division of Building Research, of which he has been the director ever since.

Mr. Legget is an Honorary Fellow of the Royal Architectural Institute of Canada and of the Ontario Association of Architects; he is also a Fellow of the Royal Society of Canada and of the Geological Society of America, and has served the Toronto and Ottawa branches of the Engineering Institute as chairman.

F. L. Lawton, M.E.I.C., Chief Engineer, power department, Aluminum Laboratories, Montreal. *(Underground Hydro-Electric Power Stations).*

Mr. Lawton graduated from the University of Toronto in 1923 with a B.A.Sc. degree in electrical engineering. In the course of his career, he was associated, during the first eighteen years, with the Canadian Westinghouse Company Limited at Hamilton, following which he joined the General Electric Company at Schenectady, N.Y., on a test course. In 1925 he joined the Quebec Development Company, resigning in 1927 to accept a position with the Duke Price Company Limited as assistant to the superintendent of operations. In 1937 he was appointed chief engineer of Saguenay Power Company Limited, successor to the Duke Price Company.

He joined the Aluminum Company of Canada Limited as assistant chief engineer in 1941, and was named to his present post with Aluminum Laboratories in 1948.

Mr. Lawton is a past chairman of the Saguenay and Montreal branches of the Engineering Institute, a Fellow and past vice-president of the American Institute of Electrical Engineers, and past president of the Canadian Electrical Association.

COVER PICTURE

Central control board at the new sulphuric acid plant of Canadian Industries Limited at Copper Cliff, Ont. at which sneltered gasses from the operations of the International Nickel Company of Canada are converted into sulphuric acid.

Photo: Canadian Industries Limited

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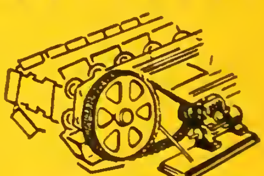
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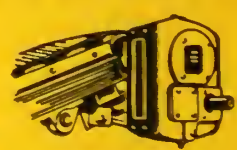
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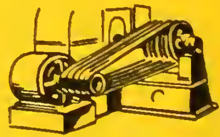
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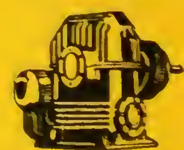
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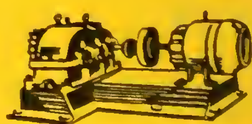
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Underground Hydro Electric Power Stations

F. L. Lawton, M.E.I.C. *Chief Engineer,*

Power Department, Aluminum Laboratories Limited

Read at the 72nd Annual General and Professional Meeting of the Engineering Institute of Canada, Quebec City, May 1958

THE paper deals with underground power plants, mostly hydro-electric, a notable development since World War II. Numerous underground hydro-electric power developments had been successfully completed and placed in service prior to World War II but most of these were located in Europe, although three early examples were located in the U.S.A. Since the war, the number of underground power plants has increased very materially. All of these have been built for economic reasons. The underground power plant has become a classic type, with a substantial influence on conventional power developments.

It is the purpose of this paper to explain why the underground hydro-electric power plant is being so widely adopted today, all over the world.

The historical development of underground hydro-electric power plants is briefly reviewed; reference is made to thermal and nuclear types of underground power stations. After dealing with the extent of present application, the reasons for this type of hydro-electric development and the economics thereof are reviewed. The impact of modern excavation methods is discussed.

In order that necessary background can be provided, the paper deals briefly with the typical elements of underground power plants. The significance of the geological formation is then considered. Attention is devoted to some special design considerations, following which operating experience is discussed.

The paper closes with a brief review of certain outstanding underground hydro-electric plants.

Historical Development

As far as known, the first development of waterpower underground was effected at Le Locle in Switzerland over a century ago, where a mill was established in a cavern on an underground stream.

About 1889 what may have been the world's first underground hydro-electric power development was installed in one of the mines of the Comstock Lode at Virginia City, Nevada. This plant comprised six 40-in. impulse waterwheels operating under a vertical head of 1680 ft., each wheel being directly connected to an electrical generator, the output of which was supplied to the mill a short distance away. The underground development received water which had been previously utilized to drive a Pelton wheel on the surface under a head of 460 ft. The discharge from this unit was conveyed through a pipe installed in the Chollar shaft to the underground station at the level of the Sutro tunnel. Some 400 h.p. was developed by this plant which rendered reliable and economic service for some two years before being supplemented by a somewhat similar plant. This latter consisted of a 36 in. diameter impulse wheel operating under a head of 2100 ft., of which 460 ft. was obtained from the pipeline of the surface plant previously noted and the remaining 1640 ft. from the drop through the Chollar shaft to the Sutro tunnel level. The impulse turbine was directly connected to an electrical generator, the output of which was supplied to the mill. (1) (2)

The Snoqualmie Falls Power Co. completed its Snoqualmie Falls development in the State of Washington, U.S.A., in 1899. This plant appears to have been the first truly underground hydro-electric power plant, designed as such. The intake is constructed about 300 ft. upstream from the brink of the 270 ft. high falls. After passing through a trash rack the power water is conveyed by two 7.5 ft. diameter penstocks to four generating units housed in a cavern 200 ft. long, 40 ft. wide and 30 ft. high, excavated in hard basalt with no regular cleavage. Water discharged from the Doble 2500 h.p. turbines, each consisting of six tangential jet wheels, with two nozzles per wheel, is returned to the river at the foot of the falls through a short 12 ft. wide by 24 ft. high tailrace tunnel. The output of the four 1500 kw., 3-phase, 300 r.p.m. 1000-volt, rotary-armature generators, excited by separate waterwheel-driven exciters, is conveyed to step-up transformers near the head of the vertical shaft. Here the 1000-volt generator output was originally stepped up to 29,000 volts for transmission some 31 miles to Seattle and 45 miles to Tacoma. Incidentally, this transmission was over stranded aluminum conductors.(3) The Snoqualmie Falls development, in its essentials, is very similar to many of the underground power developments which have since been constructed in Sweden.

The next underground plant appears to have been a small one (700 kw. in two units) at Fairfax Falls in Vermont, completed about 1904, destroyed by collapse in 1927.(13) This was followed by a plant at Breckbergmuehle in Germany, completed in 1907. This was a small power plant, with one pressure shaft supplying six Francis turbines at ratings from 930 to 1300 h.p., operating under a static head of 203 to 215 ft., with the discharge channel being an unlined grade tunnel 3600 ft. in length.

In 1910 the Mockfjard underground hydro-electric plant was placed in service in Sweden. This plant contained four horizontal Francis turbines, with a total capacity of 12,000 kw. under a static head of 79 ft., in a powerhouse cavern having a length of 105 ft., width of 31 ft. and height of 36 ft. It was soon followed by the notable Porjus development on the Lule River in Sweden, above the Arctic Circle, constructed during the years 1910-1914. Here two 538 square feet pressure conduits, one 1710 ft. and the other 2200 ft. in length, supply an open forebay from which vertical pressure shafts, or penstocks, convey the water to eight Francis turbines with a total capacity somewhat in excess of 100,000 h.p., under a static head of 184 ft. The discharge from the turbines is returned to the Lule River through two grade tunnels, each with a cross-sectional area of 540 sq. ft. and a length of 4270 ft. This development, in a granite formation, has been trouble-free throughout its existence.

The Pacific Gas and Electric Co. placed its Spaulding No. 1 underground hydro-electric plant in service in 1917, with one vertical Francis turbine operating under a static head of 197 ft. This plant has an output of 6400 kw. in a powerhouse cavern measuring 85 ft. in length by 30 ft. in width and 60 ft. in height.[13]

The nearest Canadian approach to the present-day underground power plants are the Toronto and Rankine developments at Niagara Falls. In the latter, the turbines are located in a wheel pit 171 ft. below the generator floor, with the discharge from the wheels flowing through a tailrace tunnel 2164 ft. in length. While the turbines themselves are underground, the generators are above ground.

Extent of Present Underground Power Developments

Today almost 300 underground hydro-electric power plants are in service or under construction, with an installed capacity of about 31,000,000 kw. Many more are planned, with an installed capacity of approximately 30,000,000 kw.

Underground hydro-electric plants have been widely built in Norway, Sweden, Switzerland, France, Italy and Yugoslavia. They have been constructed in at least 29 countries and this number will shortly be materially increased.

There are 60 underground hydro-electric power schemes in service in Italy,[20] with eight under construction. By 1960 the total underground capacity is expected to be 4,500,000 kw. or some 30 per cent of the total capacity for the country. Italy leads the world in number of underground plants despite very poor geological formations embracing badly faulted and jointed sedimentary and metamorphic rocks, with heavy percolation of water.

Sweden is probably second in number of underground power plants, with 26 in service having a total capacity of 2,700,000 kw. or about 50 percent of the total for the country. Another 18 plants are under construction, which will add about 2,000,000 kw. capacity.[16] By contrast with Italy, geological formations are generally good to excellent, although far from universally so.

Norway, as of 1956, had 26 underground hydro-electric plants in service, with a total capacity of 1,381,000 kw. Twelve more were under construction. Full capacity of the 38 stations will total 2,370,000 kw.

Where the underground hydro-electric plant matches geological and economic requirements, neither geography nor climate affect their use. Such plants have been built in the far north, well above the Arctic Circle, examples being the Porjus and Harspranget developments in Sweden and the Niva development in Russia. They have been built in the hotter climates such as Algeria, Brazil, Peru and El Salvador. Underground power developments of great interest have been built under far from excellent geological conditions in Brazil, Peru and Australia.

Neither head nor flow nor size limit development of water-power resources by means of underground power plants. Heads range from a low of about 36 ft. to an existing high of 3500 ft. at Tyin (Norway) and a planned high of 4822 ft. at Froges (France). The design flow ranges from as low as 15 c.f.s. at Foce Ponale in Italy to a maximum of 14,200 c.f.s. at Harspranget in Sweden.

Underground hydro-electric power plants have been built in all types of geological formation, this comprising igneous, metamorphic and sedimentary rocks. Many underground plants, as in Sweden, are built in sound, hard rocks such as granite, requiring practically no support. Some, like Sulak, are in badly fissured and even somewhat distintegrated rocks which require substantial and nearly continuous roof support.

Underground power plants now in service operate as run-of-river, storage, base-load and peak-load developments. The Palue in Switzerland and the Coghinas development in Sardinia are pumped-storage plants.

Until the Kemano hydro-electric development was placed in service in 1954, Canada did not have any underground power developments. Since then the Bersimis I plant has been placed in operation and the Chute-des-Passes plant is under construction. These plants lead the world, pertinent features being shown by Table I. [7] [8] [11] [14] [18]

Reasons For Underground Developments

In order to develop design philosophy covering the underground hydro-electric plant, it will be helpful to recall considerations which enter into the engineering, design and construction of a waterpower development.

A sound solution entails utilization of the head of a falls, rapids or stretch of river in the optimum manner, so that the lowest possible annual costs are secured. Economic studies involve interest on the necessary investment, depreciation, taxes if affected by the scheme of development, cost of operation and superintendence, and maintenance costs.

In working out of the best solution for the dam whereby the potential head in the stretch of river to be developed is concentrated and pondage created, preliminary surveys and studies are made covering cost of construction of the dam and related structures — that is, head race, power-house and tailrace, for various alternatives.

The best alternative is chosen by comparison of annual costs for all parts of the development, this varying with the actual selection of the dam site. Many factors enter into this, such as topography, underlying geological structure, unwatering procedure, etc Consideration has to be given to the value of the head created, and the storage made available, by the proposed dam; the cost of lands flooded; of coffer dams and diversion of the river during construction; of log flumes and fishways (if necessary); of the powerhouse proper; of the mechanical and electrical equipment; of the power connections to step-up transformers and the switchgear; and of all related elements.

When site conditions are such a

	Kemano	Bersimis I	Chute-des-Passes
Ultimate installed waterwheel capacity, hp.	2,400,000	1,200,000	1,000,000
Year of initial operation	1954	1956	1959 (scheduled)
Static head, ft.	2580	875	640
No. of Units	Initial 8, Ultimate 16	8	5
Waterwheel type	4-nozzle vertical impulse	Vertical Francis	Vertical Francis
Waterwheel rating, hp.	150,000	150,000	200,000
Waterwheel speed, r.p.m.	327	277	
Generator rating, kva.	106,000/122,000	120,000/138,000	
Supply tunnel length, ft.	53,061	40,294	30,854
Supply tunnel equivalent diameter, ft.	2 at 25 unlined	1 at 31 lined	1 at 34.33 lined
Penstocks, number per supply tunnel	2	8 off 1 manifold	5 off 1 manifold
Units supplied per penstock	4	1	1
Penstock internal diameter, ft.	11	Concrete 12 Steel-lined 10 to 7.75	15 to 11
Penstock design head, ft.	2850	1240	920
Penstock discharge, c.f.s.	2400	15000	
Penstock valves, diameter	51 in. double-seal Spherical	93 in. double-seal Spherical	132 in. double-seal Spherical
Powerhouse length, ft.	700-1140	565	460
Powerhouse width, ft.	82	65	70
Powerhouse height, ft.	139	80	110
Powerhouse crane capacity, tons	2 at 225	400	2 at 210
Powerhouse crane span, ft.	50	60.5	67
Unit spacing, centre-to-centre, ft.	60	55	60
Volume of powerhouse excavation in cu. yd. per kw. installed	Initial 0.347 Ultimate 0.284		
Tailrace	2 unlined tunnels, 1400 ft. long, 27 ft. wide, 37 ft. high; and 2 open-cut canals	1 unlined tunnel, 380 ft. long, 47 ft. wide, 65 ft. high	1 unlined tunnel, 9000 ft. long, 48 ft. equivalent diameter

Table I—Comparative Data for Canadian Underground Hydro-Electric Power Plants

rockfill dam is the most feasible and economical type, the best overall solution is frequently that in which rock removed from the other elements of the power development, such as the powerhouse chamber, is used for the construction of the dam.

A definite consideration in comparing development by means of a normal surface type power plant as contrasted with an underground plant is the fact that the costs of maintaining tunnels for the headrace and the tailrace, whether these latter are of the pressure or grade type, are generally lower than the corresponding elements of surface developments where concrete and steel are largely utilized. This general comment applied also to depreciation charges, as sound rock has a much longer life than the best concrete.

In this connection, recent Swedish practice in charges for renewals and maintenance, on the basis of money at 4% interest, is as shown in Table II. The difference applicable to conventional and underground power plants will be readily recognized.

The reasons favouring underground power developments on rivers with a moderate gradient, as in Sweden, may be materially different from those applying to high-head developments in mountainous areas.

Dealing with the low-head type or so-called "head" development, as utilized in Sweden, it should be noted that the marked post-war progress in methods has made it economically feasible to concentrate the head on a reach of river with moderate gradient. Some idea of this progress is shown by Fig. 1, showing Swedish tunnelling costs.

Rivers with moderate gradients do not ordinarily permit the construction of high dams. The river banks may not be very high and may adjoin valuable farmland and built-up areas which cannot be inundated on a large scale. Such conditions lead to the concentration of the portion of the head which can be economically developed by means of river-bed clearances, tunnels and canals.

While intake works may often form a component part of the dam, it is frequently more economical to lead the water from an intake so sited as to permit using a lesser total length of waterway between the intake and the point of return of the water to the river, thus reducing the cost of the water passages and, where the pressure conduit can be shortened, improving turbine regulation. Pressure conduits in the form of steel penstocks are ordinarily employed except for very low heads. If the underlying geological structure is sound and the surface is sufficiently high, the generating units can be placed in a chamber excavated underground, with the tailrace built either partially or wholly as a tunnel in rock. Such a solution leads to the shortest possible penstocks, placed vertically, in many cases. Where the underlying geological formation involves poor rock, it will be desirable to locate surface penstocks on a slope and place the power station proper at a greater distance from the intake, so that it will be a surface station with no discharge tunnel.

If site conditions provide a sound rock formation, the normal surface-type station would either necessitate

Table II—Charges to Renewals Fund and Maintenance Costs

	Annual Charges, as Percent of Investment Cost		
	Renewals Fund	*Maintenance*	*Total*
Rock Excavation, Earth Excavation, Tunnels	0.66	0.3	1.0
Earthfill or Rockfill Dam Structures	0.66	0.5	1.2
Concrete Dam Structures	0.66	1.0	1.7
Surface Power Houses, Steel Penstocks	0.66	1.0	1.7
Underground Power Houses	0.66	0.6	1.3
Gates, Steel Structures, Cranes, etc., Located Outdoors	1.0	2.0	3.0
Gates, Overhead Cranes, etc., Located Indoors	0.83	1.5	2.3
Turbines, Generators, etc	1.78	2.0	3.8

placing the turbines in deep shafts, as in the underground station with the generators at the surface, or entail construction of the station with sloping penstocks and a tailrace canal. Such a solution, with deep turbine pits and long driving shafts, is ordinarily not as economical as an underground station in rock. It is also less advantageous from the point of view of operation. Long penstocks make the problem of turbine regulation more difficult and frequently involve the use of relief valves, in addition to the added cost for the longer sloping penstocks. The additional cost of such penstocks is usually considerably greater than the saving resulting from the absence of the discharge tunnel or a shorter tunnel. The costs associated with the power plant proper must also be taken into comparison but it will be found that these are frequently no greater when the plant is located in an underground chamber excavated in rock than on the surface as the cost of removing the rock from the chamber is partially compensated for by the diminished cost of walls and roof. However, due allowance must be made for the cost of access facilities and surge chamber if these are necessitated by a long tailrace tunnel.

With high-head or so-called "tail" developments, the technical arguments in favour of a solution embracing an underground power station vary. These arguments comprise, among others:—

1. In certain cases there is no feasible site for the ordinary arrangement with surge tanks and steeply-inclined penstock or penstocks, or there may be no suitable site for location of the powerhouse in a narrow valley subject to rockslides or avalanches.

2. An underground power station can be most economically constructed when the site geological structure provides sound rock. Modern tunnelling technique may make such a solution quite as economic as a surface-type powerhouse, depending on site topographical and geological features.

3. It is possible under severe climatic conditions to continue work on an underground development throughout the year.

4. Steel-lined penstocks emplaced in massive rock, as associated with underground power stations, are much safer than ordinary penstocks located on surface and may be more economical in very rugged country. They are not vulnerable to damage by rockslides or avalanches.

5. It is frequently possible with an underground powerhouse to secure improved regulation, of the hydraulic system, or even avoid an expensive surge tank.

6. In some cases an unlined tailrace tunnel may be much cheaper than a pressure tunnel and penstock system, especially if the latter has to be provided with a steel lining.

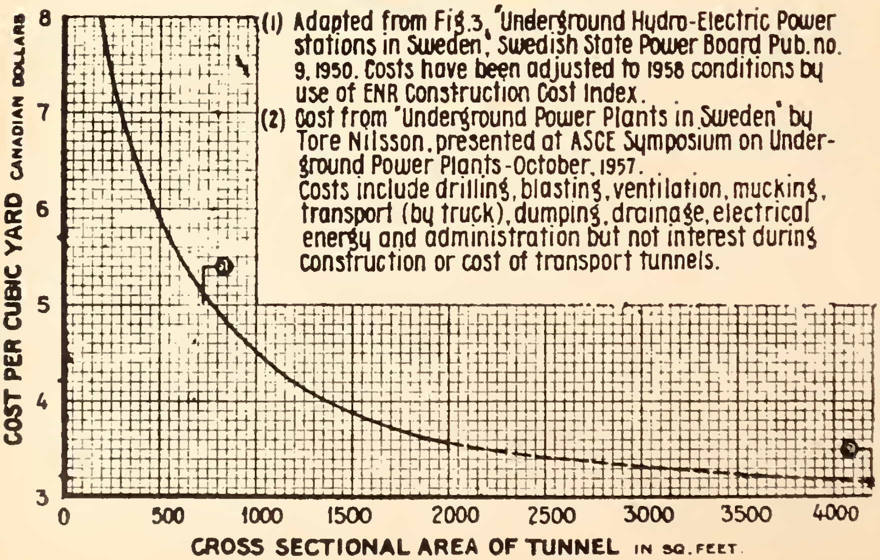
7. Location of the penstocks and power plant underground avoids the marring of scenic features.

Perhaps the major disadvantage of the power underground station is the necessity for protection of the generators against damage by water discharged from ruptured penstock connections. However, this is not a serious consideration as it is necessary to take suitable precautions in any high-head plant.

The construction of an access road or tunnel may be rather expensive, being largely governed by the topography; it may be necessary to resort to access by way of vertical shafts.

Despite the impression frequently held, even on the part of well-informed hydro-electric engineers, that an underground hydro-electric plant is so built because of its superior security in the event of aerial attack, the real reason is economic. Virtually all of the approximately 31,000,000 kw. installed capacity in underground hydro-electric power developments, which capacity is rapidly increasing, has been developed purely on economic and technical grounds. Even in Sweden, militarily exposed, underground power stations are so designed and built because they are the most economic solution, with the added advantage of greater wartime safety.

Fig. 1 Swedish Tunnelling Cost.



Typical Elements of Underground Hydro-Electric Power Schemes

Underground hydro-electric plants comprise all the elements found in the ordinary types of developments with powerhouses on the surface. These elements are:—

1. *Storage and diversion facilities*. In the case of lowhead developments, the head may be concentrated by the dam or dams forming the diversion and storage facilities.

2. *Intake works*. In low-head developments, these are frequently but not necessarily combined with the main dam constituting the diversion and storage works, and ordinarily the concentration of head in the reach of river developed. In high-head developments, the intake works are normally separate from the main dam. Intake works ordinarily consist of trash racks and control gates, together with operating facilities.

3. *Penstocks*. In low-head plants the penstocks may be relatively short, sloping or vertical, penstocks excavated in the rock, and lined or not as dictated by rock conditions. In high-head developments, the pressure conduit may be a combination of a pressure tunnel of considerable length and a sloping or vertical penstock emplaced in the rock. In such cases, a surge chamber excavated in the rock is ordinarily necessary at the junction between the downstream end of the pressure tunnel and the penstock, in order to provide acceptable pressure conditions in the penstock under fluctuating loads and limit pressure rises on rejection of load.

4. *Powerhouse*. In the case of underground power plants, the chamber

housing the generating units is excavated in the rock. Provision may be made for housing the step-up transformers adjacent to the generators in part of the same chamber or in a separate chamber. In some cases the step-up transformers are placed on the surface but there is an increasing tendency to place these underground also.

Control valves in the branches of the penstock serving individual waterwheels may be located in the powerhouse chamber or, as is frequently the case in high-head developments, in a separate chamber with its own drainage connection to the tailrace tunnel.

5. *Tailrace tunnel.* The discharge from the waterwheels may be handled through a pressure or a grade tunnel. In either case, a tailrace surge chamber adjacent to the powerhouse may be required, in order to secure stable hydraulic operation.

Fig. 2 shows the essential elements of the four basic concepts for development of underground hydro-electric power plants. A and B involve a penstock without a pressure supply tunnel and may be described as "head" developments. C and D, which are most nearly typical of high-head power plants, involve in addition a pressure supply tunnel. These may be termed "tail" developments. All underground hydro-electric power developments are essentially variants of the above four schemes.

Finally, underground power developments include means for discharging flood and surplus water by means of spillways or high-pressure outlets. As these are not peculiar to underground power plants, no further reference need be made to them.

ELEMENT \ CONCEPT	A	B	C	D
HEAD CONCENTRATION, DIVERSION AND/OR STORAGE DAM	YES	YES	YES	YES
INTAKE	YES	YES	YES	YES
PRESSURE TUNNEL	NO	NO	YES	YES
SURGE SHAFT OR CHAMBER	NO	NO	YES	YES
PRESSURE CONDUIT (UNDERGROUND PENSTOCK)	YES	YES	YES	YES
POWERHOUSE, ETC.	YES	YES	YES	YES
SURGE SHAFT OR CHAMBER (TAILRACE MANIFOLD, ETC.)	YES	YES	NO	YES
TAILRACE TUNNEL, GRADE	YES	NO	YES	NO
TAILRACE TUNNEL, PRESSURE	NO	YES	NO	YES
TYPE OF DEVELOPMENT	HEAD		TAIL	

Fig. 2. Elements in Basic Development Concepts — Underground Hydro-Electric Schemes.

Economics of Underground Power Plants

Every hydro-electric project is, in effect, "tailor-made"; it differs from all others. There is no general rule which can be utilized to determine whether a particular site is more amenable to economic development as a surface development or as an underground plant. Various alternative possibilities must be carefully evaluated in order that the most economic solution can be ascertained.

Some considerations affecting the relative cost of surface as compared with underground plants are as follows:—

1. In low to moderate-head plants, an underground development may permit a more effective concentration of head and thus the utilization of larger generating units with lower specific costs.

2. In valleys deeply filled with glacio-fluvial deposits, an underground development frequently enables utilization of lower-cost foundations for the heavy generating units.

3. Where a power plant must be sited in a narrow valley with steep walls having talus deposits encumbering the lower slopes, a lower-cost emplacement for the powerhouse can frequently be found underground.

4. Rock from underground excavations often can be used for construction of the diversion and storage dam, at a material saving in cost as compared with opening up a quarry for the provision of rockfill.

5. Although the excavation of the powerhouse proper may be relatively expensive these costs are offset by savings in the cost of walls and roof due to the use of rock as a construction element.

6. Year-round construction possible with underground developments permits securing lower costs.

7. The underground power plant frequently permits the usage of a surge shaft or chamber excavated in the rock mass as contrasted with the expensive steel tank necessary with the conventional plant.

8. The underground power plant, with penstocks emplaced in a rock mass of reasonable homogeneity, free from faults or serious fractures, may permit securing very substantial savings in steel due to the use of the rock as a part of the load-bearing structure. Frequently a shorter penstock can be used. Offsetting this are the additional costs due to longer access, cable and tailrace tunnels.

9. The underground power plant, being emplaced in a rock mass, possesses greater freedom than a conventional one from damage in an area subject to frequent and heavy earthquake shocks, such as Japan.

10. The underground power plant may eliminate the need for otherwise obligatory property purchases. The underground plant minimizes surface rights necessary.

Additional factors resulting in savings in construction costs with underground plants arise from the tremendous improvement in drill steel and drilling equipment which has taken place during the postwar period, particularly in the better quality tungsten-carbide-tipped steel. A greater appreciation of the effective use of explosives has resulted in much less damage to the rock left in place in an underground plant for use as a structural element. With better utilization of explosives, much less scaling has been necessary and hence a lower volume of concrete to replace rock which would otherwise have been utilized. Another element is that it is now possible to carry out blasting in such a way as to secure smoother residual surfaces and thus lower hydraulic losses, a matter of considerable importance in supply and tailrace tunnels.

Improvements in construction techniques used for driving vertical shafts have led to substantial economies. Nowadays a hole of suitable size is drilled, a wire threaded through to the bottom, in the underground working, and a platform attached. From this a small raise is excavated to the top, after which the opening is slashed down to final size.

Long-hole diamond drilling has been used to remove the bulk of the rock in a powerhouse chamber, following excavation and concreting of the roof arch, as at Kemano. (11)

A more comprehensive knowledge of rock mechanics and recognition of the possibilities of remedial grouting in powerhouse chambers, penstocks, surge chambers and tunnels have resulted in appreciable savings in underground power plants.

Another postwar development, adopted from mining practice, has been the usage of rock bolting for supports in large underground excavations, such as tunnels, powerhouse chambers, etc. The use of this technique, to which reference is made in more detail later, has enabled constructing underground power developments in relatively poor rock formations, badly fissured, at a reasonable cost.

However, as pointed out in another section, economic underground excavation is dependent on a correct interpretation of limited advance geological information. Thus higher allowances for contingencies should be made in estimating the cost of underground elements, although in reality these may not be incurred.

In a recent paper T. Nilsson, Civil Engineering Director, Swedish State Power Board, compared a group of conventional power plants placed in service after 1950 or under construction in 1956 with a corresponding group of underground plants. With costs on a common (1956) basis, the weighted average cost per kw. for the surface plants was 1020 Swedish crowns (a range of 640 to 1390) as compared with 720 (a range of 560 to 1140) for the underground stations. Mr. Nilsson carefully emphasized these figures do not constitute evidence underground plants are cheaper than conventional plants but nevertheless the comparison is quite striking.[16]

Table III shows the specific volume per kw. of capacity for the same groups of Swedish power plants. The striking decrease in concrete requirements is indicative of some of the potential cost savings with the underground plant.

As in any hydro-electric power project, a very careful evaluation of the various alternative solutions is necessary if the full economies inherent in an underground design are to be realized. An excellent illustration of this is the Haas power development of the Pacific Gas and Electric Co.[19]

There seems to be little doubt that the cost of excavation and the extent and nature of necessary grouting are the two most significant factors contributing to the cost of underground hydro-electric power plants.

Bergman has shown how the cost of underground excavation has declined due to improved drilling equipment by comparison with the increase in cost of reinforced concrete placed in such excavations, in Table A applicable to underground chambers in rock in Sweden.[9]

Total volume in cu. m.	*Cost of Excavation, in Sw. Cr. per cu. m.* 1946-49	1950-51	*Cost of reinforced concrete in Sw. Cr. per cu. m.* 1946-49	1950-51
10,000	47	40	63	71
20,000	40	33	58	66
40,000	34	28	51	59

TABLE A

T. Nilsson late in 1957 discussed the 500,000 kw. Stornorrfors underground plant in Sweden. It embodies a 2.5 mi. unlined tailrace tunnel carrying 28,000 c.f.s. The tunnel is 53 ft. wide and 87 ft. high, the cross-sectional area about 4200 sq. ft. Driven through good rock, the tailrace tunnel is being taken out in a 1730 sq. ft. top heading and two benches. The labour requirements are 0.56 man-hours per cu. yd. for the top heading, 0.25 for the benches and 0.37 average. Explosives needed are 1.33 lbs. per cu. yd. for the top heading, 0.97 for the benches and 1.08 average. Labour is essentially on a piece-work basis and the average wage is 7.50 Sw. crowns (Can. $1.43)* per hour.[16]

Actual costs together with estimated costs (for incomplete work) show that the total cost for excavation in the top heading is 21 Sw. crowns (Can. $4.00) per cu. yd., in the benches 13.5 (Can. $2.57) and the average 16.5 (Can. $3.14). Such costs are indicative of the low costs which have been obtained in Sweden in the postwar years. They are attributable only in part to good rock, mostly to effective construction procedures, equipment and labour.[16]

*At Can. $0.19 per Swedish crown.

Table III—Specific Volumes Per Kw of Capacity for some Swedish Hydro-Electric Plants*

Plant	*Capacity in Mw.*	*Volumes, Cu. Yd./kw.* *Rock Excavation*	*Earth Excavation*	*Earth and Rock Fill*	*Powerhouse Volume*** *Concrete*	*cu.yd. kw.*	*Type*
Stugun	35	2.8	4.0	3.9	1.12	1.90	Surface
Naverede	65	2.4	7.9	4.9	0.65	0.95	"
Jarkvissle	85	5.9	8.0	9.2	0.52	0.83	"
Stensele	45	2.8	30.0	16.2	0.60	0.73	"
Bergeforsen	130	1.5	2.3	4.3	0.92	0.63	"
Holleforsen	145	1.6	21.9	3.1	0.44	0.37	"
Porsi	160	1.7	15.3	8.1	0.88	0.37	"
Langbjorn	80	2.7	5.6	6.4	0.67	0.49	"
Umluspen	85	11.4	11.0	5.2	0.25	0.52	Underground
Grundfors	90	6.8	32.0	6.3	0.48	0.51	"
Ligga	160	4.9	1.1	4.1	0.43	0.44	"
Lasele	140	7.3	3.7	4.5	0.43	0.51	"
Stornorrfors	375	9.5	9.0	1.5	0.12	0.27	"
Kilforsen	285	7.5	7.9	4.5	0.33	0.24	"
Harspranget	350	3.5	4.0	4.8	0.41	0.19	"

* Adapted from Table 2 of Tore Nilsson's paper "Underground Power Plants in Sweden", presented at Annual Meeting of American Society of Civil Engineers, New York, October, 1957.

**Including draft tubes, but excluding penstocks.

Geological Aspects

The cost of tunnelling and removal of rock constitutes a particularly significant factor in an underground hydro-electric power development. The cost of pressure tunnels, of penstocks, of the powerhouse chamber and access shafts or tunnels, and of tailrace tunnels is influenced to a very substantial degree by the proper engineering application of advanced methods of analysis of linings, of roof arches and roof supports, and consequently on an effective determination of rock pressures and stresses. This can be most important in the case of high-head developments where the rock itself may be utilized to resist hydraulic pressures in pressure tunnels and penstocks, thus minimizing the cost of lining, normally steel in penstocks embedded in a rock mass but in some cases reinforced and prestressed concrete.[10, 17]

The proper interpretation of the geological features surrounding a power development has always been important but it is much more so with underground projects, due to the judgment which the engineer must bring to bear on the orientation of underground structures, the type and amount of support involved, the type and amount of overbreak likely to be encountered in underground excavations, the possibility and magnitude of water influxes into workings, and difficulties with some rock formations giving rise to rock bursts, "heavy" ground or "slaking" surfaces.

Geological investigations must be carried out in such a manner as to make available to the design engineers and the construction organization full information on the geological structure and the physical properties of the rocks involved in the scheme. The information should be sufficient to determine the probable stresses on exposed rock faces and on any lining in pressure tunnels, penstocks, surge chambers or grade tunnels, as well as the economic cross-section of tunnels suited to the particular rock formation, optimum driving procedures, the best methods of taking care of infiltration of water and thicknesses of linings. It is well to bear in mind that underground power plants are built, not of concrete or steel, for the greater part, but of rock in place, a building material about which not too much is known as yet.

In this connection theoretical considerations have led to marked advances in the design of the various elements of underground power developments. However, experimental methods permitting determination of the deformation of the rock structure under loading so that the elastic properties of the rock, the time lag of plastic deformation and any lack of symmetry can be fully ascertained and properly applied in the design, are invaluable. Nevertheless, it must always be remembered that rock in situ is neither homogeneous nor isotropic. Its properties vary from point to point in what appears to be a uniform formation.

The engineer concerned with planning and design for an underground power scheme must be able, on the strength of advice from the geologist, to appraise the probable behaviour of the formation in which a tunnel or powerhouse chamber excavation is located. Will the formation arch favourably? For example, if the strike of the formation is parallel to the axis of the excavation a weak arch may be anticipated as contrasted with a stronger one when the strike is at right angles to the axis. Proper interpretation of the geological facts will enable a correct assessment of the magnitude and type of outbreak and thus an appraisal of, for instance, rugosity in unlined pressure tunnels.

The significance of a thorough understanding of the site geological features can be appreciated from a discussion of their relationship to the design considerations associated with the pressure conduits or penstocks in an underground power scheme. While the design of surface penstocks is founded on a rather definite basis, design of pressure conduits or penstocks emplaced in a rock mass is much less tangible. The major problem is: What is the distribution of load between the steel liner and its surrounding rock envelope? Design is influenced by many variables introduced by the natural site conditions and the construction techniques utilized. Some of these are jointing, stratification, attitude and residual stresses of the rock formation; variations in strength and modulus of elasticity of the rock; shrinkage and imperfection of concrete in the backfill between liner and rock envelope; and variations in properties of the steel liner, even though furnished to standard specifications. Experience has demonstrated that, with a penstock emplaced in a rock mass, the rock acquires a permanent set under initial loading, with a tendency to modification of the contact between the liner and the concrete backfill under normal service conditions.[14]

A thorough understanding of the rock mechanics of the geological formation involved in a given development is important. Lack of much fundamental knowledge of the elements is one of the reasons why the design of embedded penstocks or pressure conduits is more of an art than a science at present. This is most applicable to rock mechanics, in which connection Lord Kelvin's famous observation —

> "When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge but you have scarcely, in your thoughts, advanced to the stage of science whatever the matter may be"—

is particularly appropriate.

The significance of adequate knowledge of the properties of rock will be apparent from a brief consideration of the interaction between the steel liner and the surrounding sheath of concrete backfill and rock in an embedded penstock. Assuming the liner is in intimate contact with the concrete sheath around it, the interaction is about as follows:—

1. The internal pressure in the penstock will cause the steel liner to increase slightly in diameter, under the hoop stress set up, and tend to shorten longitudinally; being restrained, longitudinal and transverse stresses will be set up in the girth welds, at joints.

2. Expansion of the steel liner will transfer some load to the concrete sheath, thence to the rock; at the same time hoop stresses will develop in the concrete sheath. If these hoop stresses exceed the low tensile strength of the unreinforced concrete sheath it will develop minute cracks.

3. That part of the internal hydrostatic pressure load transferred to the rock immediately adjacent to the sheath will cause it to plasticly deform to some unknown degree. This will continue until "packing" under load has taken up the fissure and void spaces which exist naturally or arise from shaft-driving operations and are not completely filled with grout. Some minute cracking of the rock can be anticipated in the vicinity of the penstock since the tensile strength of rock is moderately low, compared with its compressive strength.

4. When the steel liner, surrounding grouted concrete backfill and rock sheath reach equilibrium under normal operating and maximum surge pressures, the stress in the steel should not exceed a "safe" value under the worst conditions of operation and corrosion foreseeable.

5. When the penstock is drained for maintenance work, the steel liner, if

it has not been stressed previously beyond the elastic limit and undergone sufficient permanent deformation, will decrease in diameter more than the surrounding grouted concrete backfill and rock sheath which has previously incurred a permanent plastic (packing) deformation plus some elastic deformation. Obviously the smooth external periphery of the liner will tend to separate, to some extent, from the surrounding sheath. Such a separation gap, through the fissures and hairline cracks in the grouted concrete backfill and rock sheath, will fill with ground water under such pressure heads as exist in the formation through which the penstock runs.

6. Provided such external pressure heads are insufficient to cause inward buckling, refilling of the conduit and its return to service result in the steel liner and surrounding sheath resuming its loaded state as before.

The proportion of load from the internal hydrostatic pressure transmitted by the steel liner to the rock can be calculated if the moduli of elasticity of the steel and of the rock are known, the elastic deformation of the liner in the radial direction being equated to the radial deformation of the rock. The principal difficulty with this procedure is lack of knowledge as to the real value of the modulus of elasticity of the rock formation traversed by the penstock. The important consideration is that stresses in the liner, under any service condition whatsoever, remain below the yield point of the steel.

During the last decade, rock bolting has come to the fore as an economic means of providing support in excavations for underground hydroelectric power developments, eliminating to a substantial extent use of the more expensive steel sets.

Rock bolting consists of drilling a hole into the formation involved, inserting a wedge and split-end bolt of suitable length and diameter, and tapping it with a hammer to wedge the split end of the bolt tightly into place. A steel plate-washer is placed over the free end of the bolt and a nut is screwed on and seated against the plate washer. Tightening of the nut with an impact wrench results in high friction being developed between the spread end of the bolt and the rock. Depending on circumstances, a steel channel or other member may serve as a washer for two or more rock bolts.

Other forms of rock bolts have been used. For instance, at the Pacific Gas and Electric Co.'s Haas underground plant, the Perfo method of the Sika

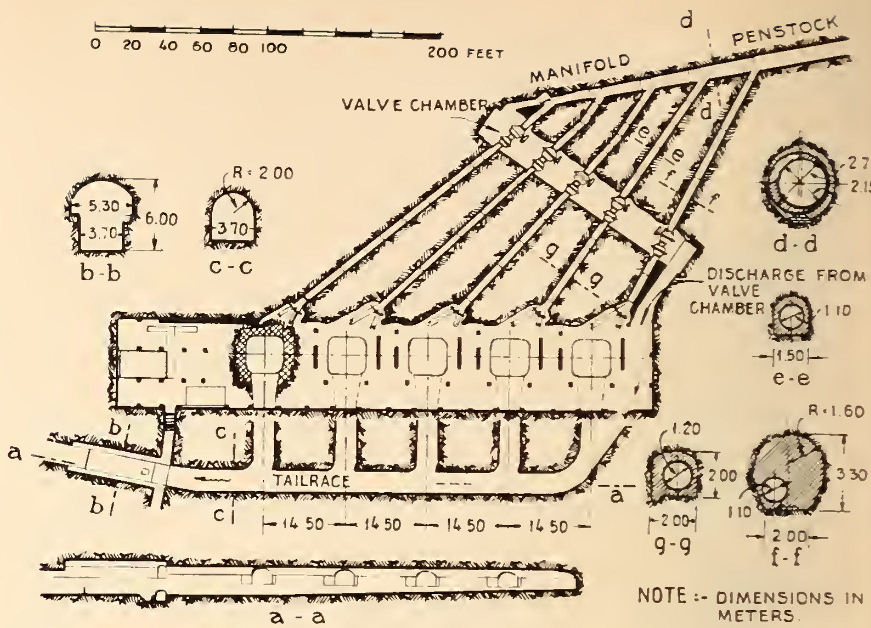


Fig. 3. General Plan of Innertkirchen Underground Power Plant.

Chemical Corporation was used. This involves two half-round perforated tubes of sheet metal the full length of the hole which are filled with a stiff sand cement grout and then wired together. This is inserted in the hole and the reinforcing bar serving as the rock anchor is driven in by an air hammer. The volume of grout is such that a small amount is extruded as the rod is driven to the end of the hole.[19]

At Stornorrfors, in Sweden, a procedure for rock bolting, known as the SN method, is claimed to develop greater stress and be more reliable than the conventional technique. The method involves inserting the bolts into the holes and then forcing in grout, beginning from the bottom, under air pressure.

Rock bolting is generally effective in slabby or blocky rock and in such rocks as shales, slates, some sandstones and coal. They are not very effective in soft shales, soft sandstones and similar formations.

Rock bolting, properly used, can be very economic but there is a clear necessity to apply it only under the direction of an engineer. Psychologically, what appears to be a thoroughly-rock-bolted formation may convey a strong sense of security to underground workers; contractors' representatives are inclined to look favourably on such a practice, as eliminating otherwise necessary scaling, especially when the owner is paying for the application of the rock bolts. However, indiscriminate use does not necessarily secure expected results, in the form of the safety anticipated.

A moot question relates to the effective life of rock bolts where installed in the presence of a corrosive water content in the rock formation. In Norway, cement-grouted stainless-steel bolts have been used, in some cases. In Canada, aluminum-alloy bolts have been used, in one instance.

Lang has observed that "The view . . . rock bolts only 'pin' or 'nail' blocks or slabs of rock which are loose to the sounder rock behind them is erroneous". It is true they have been used for this purpose for a long time but such usage without a thorough knowledge of the controlling factors can be dangerous. Properly speaking, rock bolting means the planned use of rock bolts to convert a jointed rock into a structural entity of adequate competence for the part played by it in an underground structure.[15]

Lang has noted "Another concept in regard to the behaviour of rock bolts, is that they create a principal compressive stress normal to the free surface of an excavation where, without them, there would be only one principal stress parallel to the surface. This is borne out by their very effective use to stabilize "popping" rock. This implies that, either at or immediately behind the free surface, the bolts form a diaphragm of material somewhat less in thickness than the length of the rock bolt, which can be used as a structural member whose properties can be ascertained and whose behaviour can be assessed and designed for. It is obvious that, if rock bolts are to be designed to carry out the tasks enunciated above, then it is necessary to know their behaviour in relation to both intact and jointed rock. This requires not only knowledge of the behaviour of rock bolts but also the behaviour of jointed rock, either with or without rock bolts".[15]

Design Considerations

It will be apparent, from the discussion of the geological aspects associated with an underground hydroelectric power plant, that design considerations can only be finalized when the working area has been reached, either by a shaft or tunnel intended for permanent use or for exploration only, although normally it will be utilized as part of the permanent facilities. Inspection of the geological formation may well indicate, for instance, the desirability of changing the orientation of the powerhouse longitudinal axis, in order to secure a stronger roof or minimize wall support.

A basic precept applicable to underground power projects is that the design of the scheme should be made in principle only, prior to effecting entrance to the working area.

There are no fundamental differences between the intake works for the classical type of power project and the underground type, so there is no need to comment on design aspects for this element.

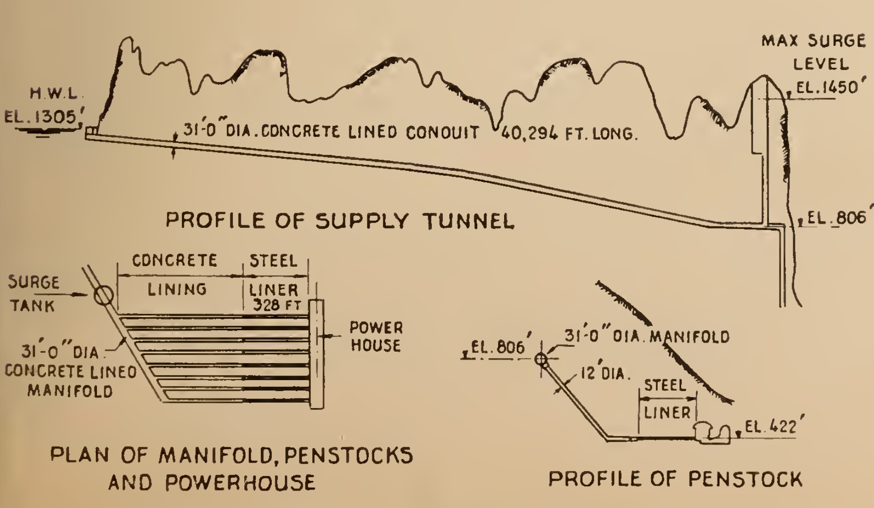
In the case of pressure tunnels, the decision as to whether these should be lined or unlined is purely a matter of economics. The higher coefficient of friction with an unlined tunnel may dictate a substantial increase in effective diameter, which must be weighed against the cost of lining a smaller tunnel.

Surge chambers in the pressure conduit are not ordinarily required with low to medium-head underground developments. Thus, so-called "head" developments do not involve surge chambers on the pressure conduits. The long pressure tunnels and penstocks associated with high-head or so-called "tail" underground power plants normally involve surge chambers on the pressure line. These may consist of either a vertical or an inclined shaft, with one or more chambers of various sections. The entire structure is excavated in the rock and may be unlined or concrete lined. In some plants, surge chambers with restricted orifices are used. Care must be given to the provision for spilling any water ejected from the surge chamber during load rejection.

In the case of low-to-medium-head or "head" developments, separate penstocks are ordinarily used for each turbine. On the other hand, the high-head or "tail" developments normally have one or more penstocks from the surge chamber to the powerhouse, these penstocks branching off to the individual turbines just upstream from the powerhouse chamber.

Embedded penstocks are designed to take full hydrostatic head. In all cases they are concrete lined and frequently a steel lining is added, the steel lining increasing in thickness from the top to the bottom of the pressure shaft. At Krangede, for instance, the upper part of the pressure shaft is lined with 25/64 in. steel, increasing to 1-1/32 in. steel in the lower part. The upper part was not grouted and the space between the concrete and steel linings is used for drainage; the lower part of the shaft was pressure grouted. At Hjalta, with a static head of 285 ft., the pressure shaft was lined only with concrete, 8 in. thick at the top and 12 at the bottom. By proper attention to design, taking full advantage of the strength of surrounding rock, selection of optimum grouting pressures and of the economic form of lining, the overall cost can be minimized.

Fig. 4. Bersimis 1.



The design of underground penstocks has been discussed in connection with the geological aspects. The design considerations relative to internal pressures are well recognized. However, treatment to withstand external pressures, when the penstock is drained, is on a less satisfactory basis. Some designers provide an external drainage system consisting of drainage pipes running parallel to the penstock and tapping the rock envelope. However, these are liable to become clogged during grouting operations or later. Other designs rely on bonding the liner to the concrete envelope through various forms of spines and brackets. Still others provide an inspection gallery adjacent to the penstock, as at Gerlos in Austria. Main reliance, however, is placed on effective grouting.

An important consideration in the design of an underground hydroelectric power plant is securing such a layout of the pressure tunnel, penstock manifold and penstocks that hydraulic losses at deflections and branches are minimized. Note Figs. 3-6, inclusive, showing the arrangements at Innertkirchen, Bersimis I, Chute-des-Passes and Kemano, respectively.

Particular attention must be paid to water tightness of the lower part of the penstock in order to minimize the entrance of ground water into the chamber constituting the power plant proper. In many cases, provision is made for the elimination of such ground water by ducts connecting with the tailrace. Well-planned grout curtains are most commonly used. At Sudagai, in Japan, a grout curtain is combined with an inner curtain of upward-drilled drainage boreholes emptying to a drainage tunnel around the plant.[21]

In the case of low-to-medium head developments, control of water passing through the pressure conduits is ordinarily provided by various types of intake gates, but several forms of valves are sometimes utilized. In the case of high-head developments, a valve is ordinarily located at the upstream end of the penstock. Such valves are frequently butterfly valves, as at Kemano and Haas.[14, 19] Control is ordinarily provided such that these valves close automatically on the occurrence of excessive velocities associated with a ruptured conduit, valve, turbine scroll, etc. However, in some cases, as at Fionnay, these valves are eliminated and reliance is placed on automatic closing devices at the tunnel intake. Ample provision for automatic air inlet must be made just downstream from such valves or closing devices to avoid collapsing of the penstock liners due to vacuum. Unit valves are ordinarily installed on the branch connections to the individual turbines. These may be single or duplicate valves, as used at Innertkirchen. Various types of valves are used, such as cone, butterfly, spherical or cylindrical, depending usually on the head involved. These valves may be operated by hydraulic or electric control mechanisms. They are sometimes automatically controlled by the turbine governor. Current practice is to utilize the double-seal type so that a single valve meets all requirements for maintenance.

The valves may be located in a separate chamber as at Innertkirchen and Kemano; in a passage between the penstock tunnel and the powerhouse; or in the powerhouse proper, as at Brommat and elsewhere. Actual location is governed to a substantial extent by the nature of the rock formation. Placement of the valves in a separate chamber reduces the necessary width of the chamber required for the generating units but does necessitate a separate crane and access passage. The overall volume of excavation is somewhat greater. In the case of high-head developments, where serious consideration must be given to the possibility of a ruptured pressure line, the valve chamber is ordinarily provided with its own discharge tunnel connecting with the tailrace. See Figs. 3, 7 and 8.

As to the powerhouse proper, it is obvious that size, construction and cost are influenced to a marked extent by the choice and arrangement of turbines, generators and auxiliaries. Large, high-specific-speed units contribute to a substantial saving in installation and maintenance costs, in common with experience with the classical type of power development.

Horizontal and vertical generating units have been widely used, with the vertical units preferred for low-to-medium heads. For high-head developments, horizontal impulse waterwheels are normally used in Europe although at Innertkirchen twin-nozzle vertical impulse units were selected. At Kemano four-nozzle, vertical impulse units were installed. Horizontal reaction turbines operating at 164 ft. head were selected for the Guayabo underground plant on the Lempa River in El Salvador. See Fig. 9.

Although many changes in the type and arrangement of the major equipment in underground power plants have been worked out since the early plants were built, present practice, aside from the Guayabo and Ambuklao developments, definitely involves vertical units. Most of the later schemes have been this type—for instance, Krangede with its six 54,000 h.p. units, Innertkirchen with its five 66,000 h.p. units, Hjalta with its three 73,600 h.p. units, Hojum with four 78,500 h.p. units, Soverzene with its four 90,000 h.p. units, Harspranget with its four 130,000 h.p. units,

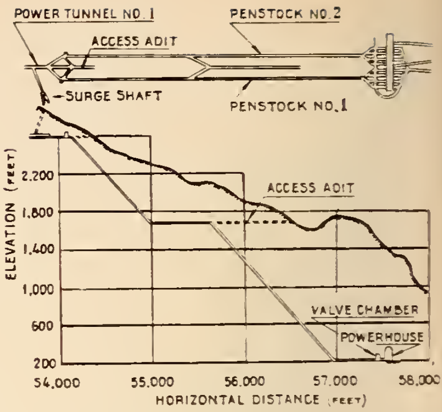


Fig. 6. Kemano Penstocks Nos. 1 and 2.

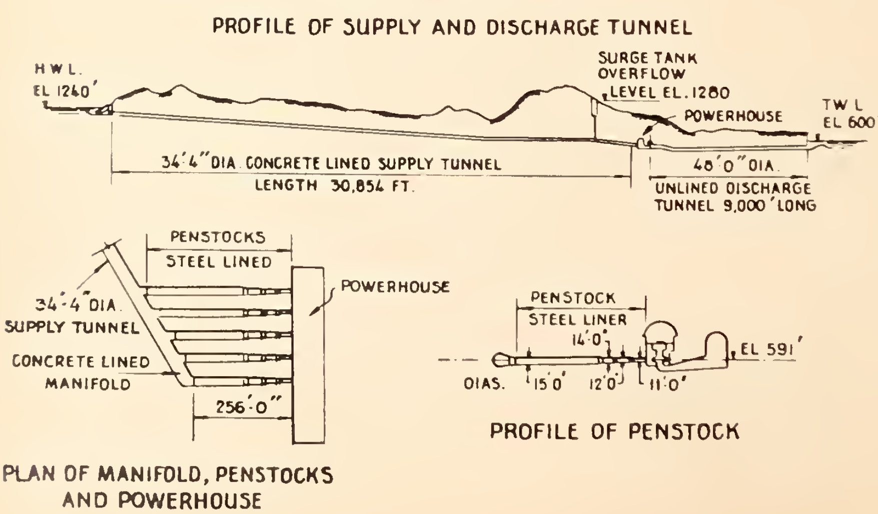
Kemano, with its ultimate sixteen 150,000 h.p. units, Bersimis 1 with its eight 175,000 h.p. units and Chute-des-Passes with its five 200,000 h.p. units. A governing consideration in the selection of vertical generating units is minimum excavation and minimum width. See Figs. 10 and 11.

Advantages claimed for the horizontal reaction turbine setting, as used at Guayabo and Ambuklao, are lower excavation volume, better hydraulic efficiency due to elimination of one penstock bend and the elbow draft tube bend, and separate erection and dismantling of turbine and generator. Disadvantages are the special handling facilities for the turbines, slow unwatering, and special handling and working conditions associated with the turbine erection.

Some of the significant data for the Kemano, Bersimis 1 and Chute-des-Passes underground developments, as shown by Table 1, indicate the marked progress which has been made in this direction.

An underground power development will entail less excavation for the chamber housing the generating units if requirements for headroom are kept to a minimum. This was accomplished at Krangede and at Innertkirchen by the development of a structural steel support interposed between the generator and waterwheel casing, whereby the generator dead load and the hydraulic thrust is transferred through the steel supporting structure to the waterwheel casing, without intervening concrete piers. Another means of minimizing head-room requirements is the selection of umbrella-type generators, with combined guide and thrust bearing below the rotor. Still another method is the use of station cranes specially designed to minimize head-room requirements. Finally, considerable thought is being

Fig. 5. Chute-des-Passes.



given to the elimination of high-capacity station cranes, used during erection and very seldom thereafter, by the provision of built-in jacking facilities whereby the generator stator can be lifted to permit access to and removal of the rotor.

Considerable economy in the cost of the chamber housing the generator units can be affected by giving proper attention to the structural features, taking full account of the strength of the rock. The powerhouse chamber usually has a semi-circular or elliptical roof and vertical walls. In the case of relatively weak rock structures, the roof arch is used to carry the full load. In sound rock, the arch is designed for only a part, in some cases as low as 25%, of the estimated rock load. The roof arch is abutted into recesses in the rock walls, thus transferring the load into the walls, reducing the stresses in the free vertical faces of the rock and stabilizing the walls.

At Krangede, reinforced inverted T-beams were used in the roof arch, so that an interspace between the rock and the ceiling resulted, which picks up any infiltration of ground water. Normally, the roof arch is monolithic concrete, placed against the rock and grouted. In such cases, a suspended second arch is frequently provided, ordinarily quite thin, with a waterproof membrane on top. Such a solution was adopted at Brommat and at Innertkirchen. At Brommat, gutters collect the infiltration of ground-water which accumulates on the second arch. Roof arches have been built of hollow concrete blocks, pumice blocks and brick. One form of roof-arch construction employed in some Swedish plants is illustrated by Fig. 12.

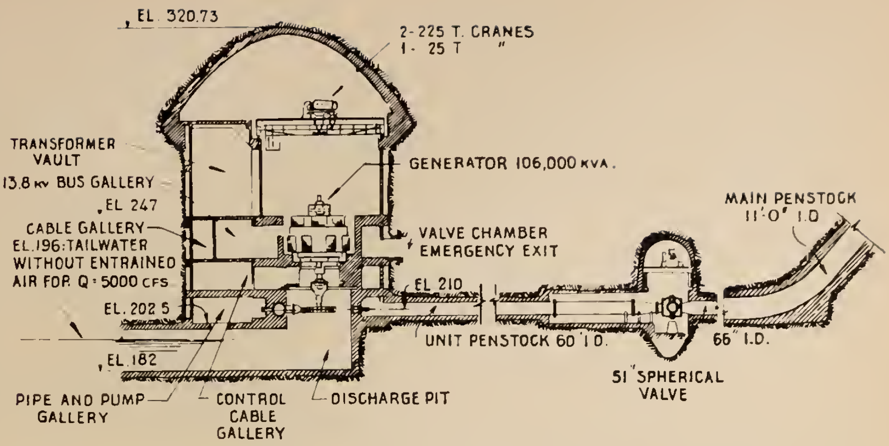


Fig. 7. Cross-Section Through Kemano Valve and Power Chambers.

Ordinarily, in good rock formations, the rock walls need no support. An exception was Soverzene where a weak zone was supported by a reinforced concrete wall. Sometimes vertical arches are used for the support of horizontal loads. While the rock walls are sometimes gunited and frequently concreted, in many cases it is possible to leave the walls as excavated. Properly sealed and cleaned, such bare rock walls constitute a very attractive feature of many underground plants.

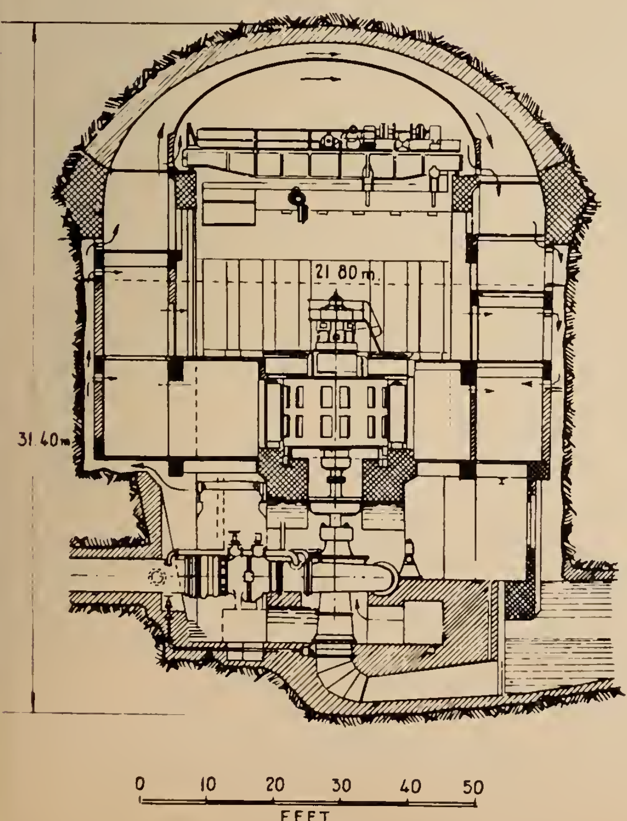


Fig. 8. Cross-Section through the Brommat Underground power plant utilizing the waters of the Truyere and Bromme Rivers, France, and constructed from 1928 to 1933.

Although the walls of underground power-plants are normally vertical, with a semi-circular or elliptical roof, high rock pressures in a bad geological formation may necessitate another form of cross section. For instance, at Santa Giustina, in Italy, an elliptical cross-section is used with the generator floor heavily reinforced to resist a high horizontal component of the rock pressure from swelling of the marls in which the plant is emplaced. A parabolic shape was used at Peccia and Cavergno for a similar reason.

In many underground hydro-electric power plants, the designer has provided a second wall with an interspace between the rock and the wall through which air is circulated, thus removing accumulations of moisture accruing from groundwater penetrating to the rock surface. Such a solution was adopted at Brommat and at Krangede. Note Figs. 8 and 10.

Ordinarily the powerhouse cranes in underground stations are carried on beams supported on free-standing columns, independent of the rock walls. Such a solution has been widely adopted, an instance being the Lavey development in Switzerland as in Fig. 13. At the Forsmo and other developments, the crane bridge extends downstream over the draft-tube stop logs, so these can be operated by the crane. In some plants special galleries with monorails and other lifting devices are provided for the operation of draft-tube stoplogs or gates, as shown by Fig. 14. At Krangede these are operated from the vent shaft while at Soverzene they are handled from the transformer gallery. A special consideration in the design of the powerhouse chamber is that of proper provision for handling a break in the penstock, valve, casing, etc., whereby a substantial volume of water could be released. In Sweden, the practice is to reinforce the concrete floor to take full water pressure. In many Italian plants, turbine floors are designed only for the pressure from surges in the tailrace tunnel. At Innertkirchen and Kemano, the valve chamber is drained to the tailrace tunnel by a separate tunnel.

Underground powerhouses are particularly adaptable to a pleasing architectural treatment, if proper consideration is given to this at an early stage. The arched roof can be quite attractive. It is possible to work out very economical and pleasing indirect lighting. This is particularly evident to anyone familiar with the classic types of power plants who visits underground schemes and examines them critically. Decorative murals or frequently clean bare rock walls constitute attractive features in some plants.

Fire protection is no more difficult with an underground power development than with the surface type but more consideration has to be given to removal of fumes resulting from a fire. Suitable close-sealing fire doors are desirable where transformers are installed immediately adjacent to the generating units, as at Kemano. Either CO_2 or water-spray fire protection can be utilized, depending upon the requirements of the protected apparatus.

An important problem in underground hydro-electric plants is that of adequate ventilation. Fresh air is normally taken from the surface and circulated by fans through an access shaft or tunnel into the powerhouse or through a separate ventilation shaft or tunnel, which in some Swedish and other plants serves as a cableway for outgoing power cables. In some cases the air is filtered or dehumidified. In other instances the air is cooled in heat exchangers using water pumped from the tailrace or with the heat exchangers inserted in the tailrace. In some plants the incoming air is conditioned by drawing it in over the water in the tailrace. The incoming cooled air is circulated initially through the generators, either in a closed or open circuit, through the powerhouse interior and through the interspace between the rock walls of the chamber and the inner shell of the powerhouse. This is the case at Brommat. In lower-head developments warm air from the powerhouse proper passes to the intake works in order to provide temperature conditions conducive to prevention of ice formation on the trash racks, etc.

The tailrace tunnel is one of the most important elements of an underground power scheme in its bearing on the overall economy. This is particularly true in the case of low-to-medium-head plants where the investment in the tailrace tunnel may represent a substantial part of the overall investment. Tailrace tunnels, with a gradient of 0.01 to 0.025, are usually constructed as unlined grade tunnels designed for a velocity of six to eight f.p.s. The usual cross-section is either horseshoe-shaped or egg-shaped, but

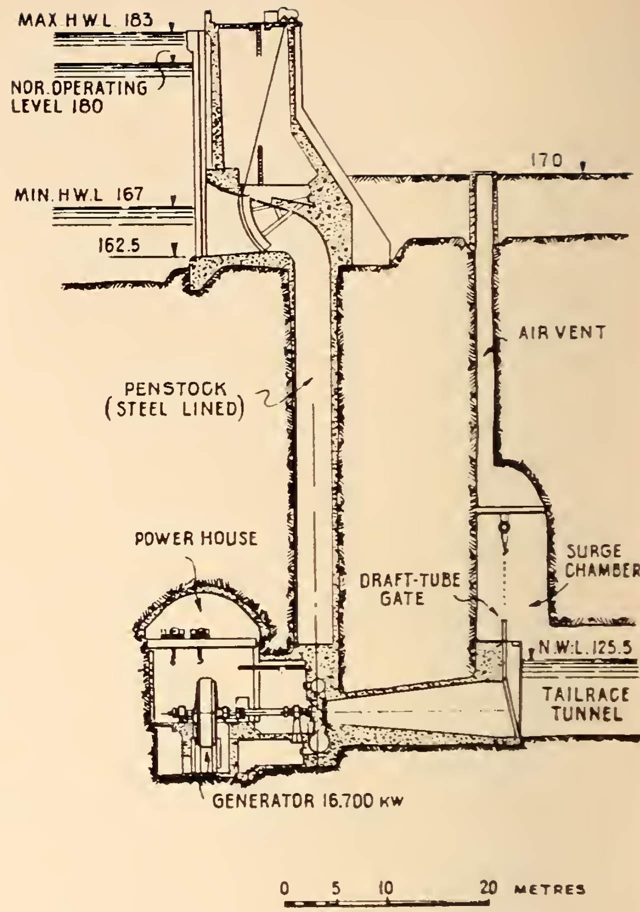


Fig. 9. Cross-Section through the 75,000 KW. ultimate capacity, 188.6 ft. gross head Guayabo Hydro-electric plant on the Lempa River, El Salvador.

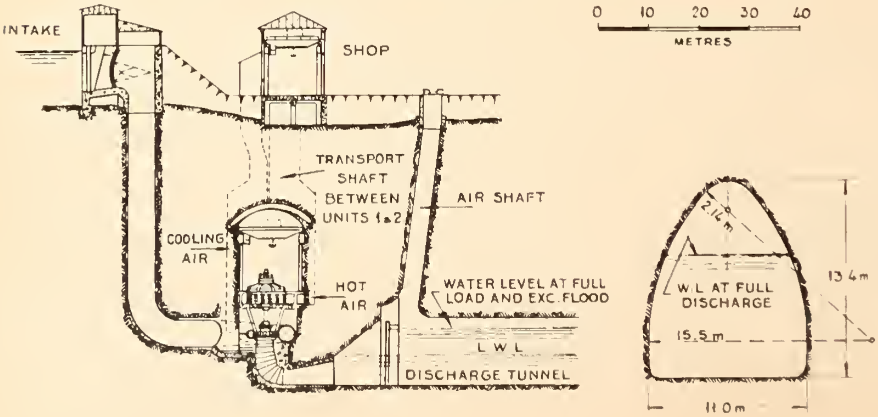


Fig. 10. Krangede Underground Power Plant showing, a) cross-section of Power Plant and b) cross-section of Tailrace Tunnel.

a triangular cross-section was employed in the Niva development. This Russian power plant utilizes a head of 243 ft. between its intake on the Niva River and Kandalaksha Bay. The inverts of the draft tubes and of the tailrace tunnel fixed the flow line in the tunnel at a slightly higher level than that of the tide, permitting full utilization of the available head. The lined 7,215 ft. long grade tailrace tunnel has essentially a triangular cross-section 27 ft. wide by 35 ft. high. It discharges to a lined, open-cut tailrace canal just under 2400 ft. long.

The tailrace tunnel handles a fluctuating flow, depending on load variations. Consequently, it is feasible to design the tunnel in three different ways hydraulically. In the first, the tailrace tunnel is designed to act as a free-surface grade tunnel at all times, not only when carrying steady full-load flow, but also the maximum surge flow or wave arising from rapid fluctuations in load. Under such circumstances, the cross-section is large but it is not necessary to provide a surge chamber or shaft adjacent to the power plant proper.

The second method is to design the tunnel as a free-surface (grade) tunnel at steady flows but filled by the surge wave resulting from fluctuations in flow, at which times the tunnel acts as a pressure tunnel. This entails an enlargement in the form of a surge chamber at the head of the tunnel adjacent to the power plant.

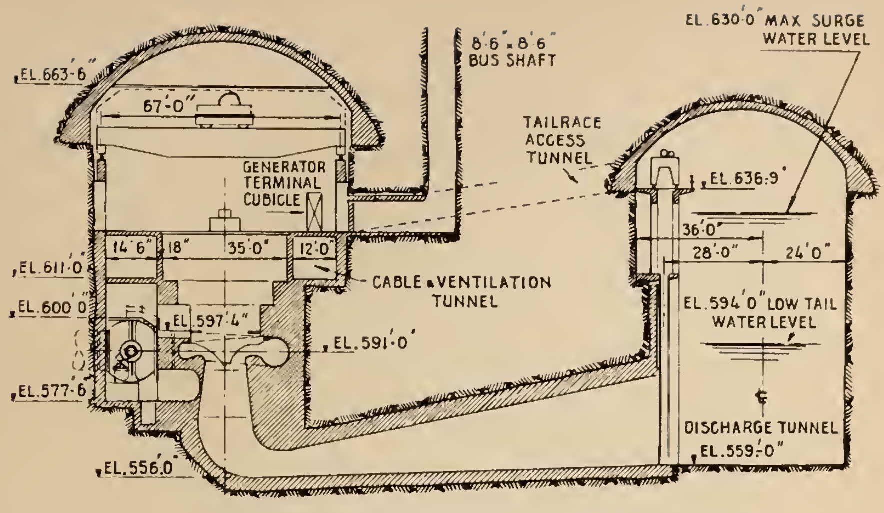


Fig. 11. Cross-Section through Chute-des-Passes Power Plant.

The third method treats the tailrace tunnel as a pressure tunnel during steady and unsteady flows, requiring a surge shaft or chamber and a vent shaft.

For tailrace tunnels up to 1500 or 2000 ft. in length, the economical choice appears to be the first type. As the length increases, a horizontal surge chamber in the form of an enlargement reduces the average size of the tunnel cross-section and is advisable for tunnel lengths of 7000 to 9000 ft. For the longer tunnels, surge shafts appear to be more economical. The economic solution for the proper accommodation of unsteady flow or surges in tailrace tunnels can best be ascertained from model tests.

Control rooms for underground hydro-electric power plants occasion no more difficulty than with the conventional type of power plant. Occasionally, as at Krangede and Bersimis I, the control room is placed at the surface.

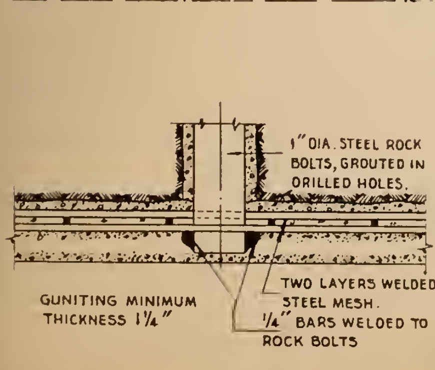
Step-up power transformers associated with underground power schemes have been placed both underground, in cuts and on the surface, but there is an increasing tendency to place this equipment underground. Switchyards are almost invariably placed on the surface. Where transformers are installed underground, they may be placed at the same level and opposite to the generators, in an extension of the generator room, or in a separate chamber adjacent to the power chamber. The highest voltage so far employed for transformers placed underground is 400 kv., used at the Harspranget plant in Sweden. See Figs. 15 and 16.

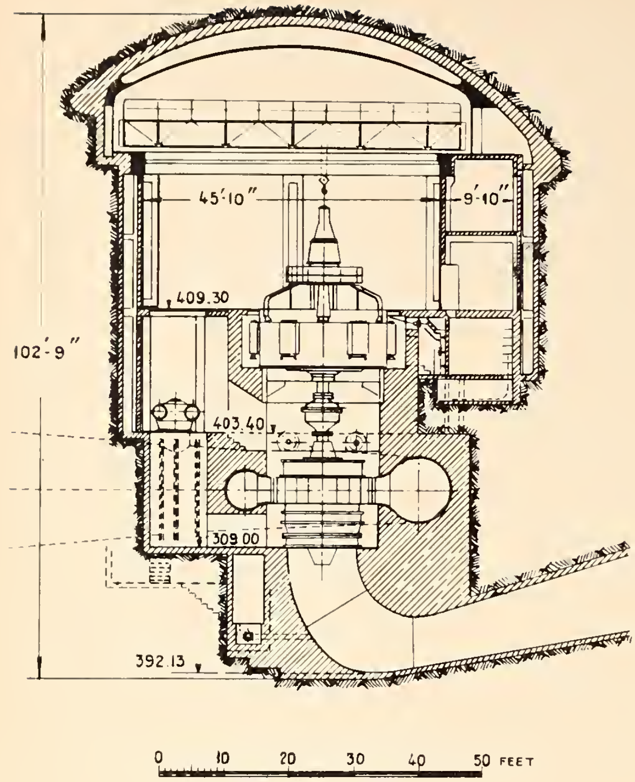
Connections between the generators and their transformers can be either bus or cable, depending on the economic solution in the particular case. Where the duct, tunnel or shaft carrying the high-tension leads from underground transformers to the surface is long, high-voltage cables to the switchyard are ordinarily used, as at Kemano.

An important element associated with underground power developments is means of access and exit. The nature of communications depends largely on the relationship of the power chamber to the surface, as this fixes whether a vertical shaft or a horizontal or an inclined tunnel is the most economical solution. Duplicate means of ingress and exit are desirable, from the psychological viewpoint, but are not always provided as cable ducts and other features can be used for emergency exits. Low-to-medium-head developments ordinarily utilize vertical access shafts while high-head developments normally have horizontal access tunnels. Brommat is an instance of an underground development with an inclined shaft. Haas, the first modern underground power plant in the U.S.A., provides emergency access and exit through the upper section of the tailrace tunnel. [19] See Figs. 10, 15 and 16.

The dimensions of shafts or tunnels providing access to an underground power plant from the surface are governed by the largest pieces to be moved into the plant. Vertical shafts are ordinarily smaller in cross-section than sloping or horizontal tunnels. However, the excavation of shafts is more expensive than that of tunnels and freight elevators are necessary,

Fig. 12. One method of treating the roof of Swedish underground generator chambers.





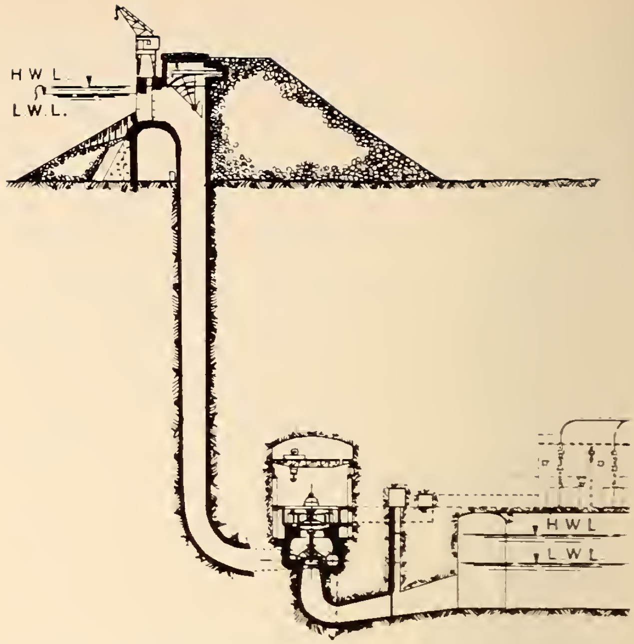


Fig. 13. Left: Cross-section of the low-head Lavey underground power plant in Switzerland.

Fig. 14. Above: A Typical Swedish underground power plant emplaced at a substantial distance below the surface.

whereas horizontal or sloping tunnels can be provided for rail transport, as at Innertkirchen, or truck transport as at Kemano and Chute-des Passes.

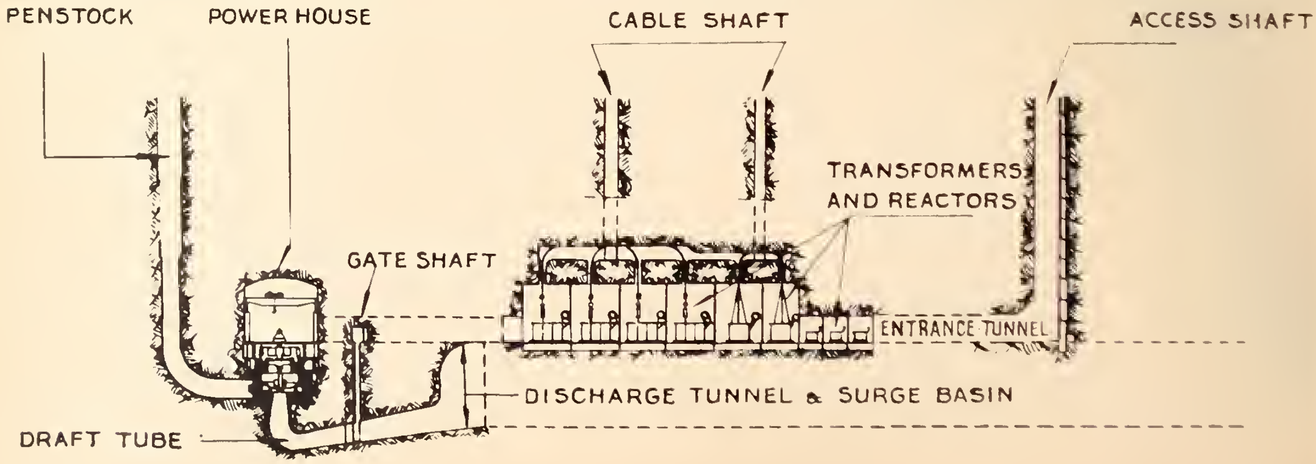
Careful consideration has to be given to moisture in underground power plants. Mention has been made of this as being provided through the use of interwall spaces, properly designed grout curtains, ventilating means and other features. It is of particular significance in connection with corrosion, particularly where rock bolting is relied on for the stability of walls and arches.

Operating Experience

Operating personnel in an underground power plant is about the same as that required for a conventional station. No direct disadvantage in the operation or maintenance of underground stations can be observed by comparison with surface stations.

Experience with underground power plants has shown that personnel find working conditions quite acceptable. It is true that an operator in an underground station does not have an opportunity of seeing the sun during his period on shift, but aside from this there is no difference between conditions in the two types of stations. With the underground plants, working conditions are more equable. Psychological factors may have some bearing but no difficulties have been experienced on this account because the power-station employee works in a dry, well-heated, well-ventilated and well-illuminated working area barely distinguishable from the normal station. In extensive power systems with both types of stations, there has been no noticeable tendency among the staff to apply for a discharge or trans-

Fig. 15. Vertical section through Harspranget underground power station, Sweden. At full development four Francis turbines will generate 96,000 KW each under a net head of 346 ft. using 15,120 C.F.S.



fer to a surface station, indicating apparently no discomfort is associated with working in an underground plant.

The author's own observations indicate that underground power plants are just as attractive as conventional plants from the point of view of comfort. There is usually less noise and vibration. Well-designed underground power plants with good lighting and even atmospheric conditions produce absolutely no impression or feeling of claustrophobia.

In an underground hydro-electric power station where full consideration is given to proper ventilation and associated air conditioning with control of humidity, good lighting and an attractive colour scheme, working conditions are fully acceptable. This was demonstrated by experience with underground factories in Germany, Japan, Italy, Czechoslovakia and Sweden during the war.

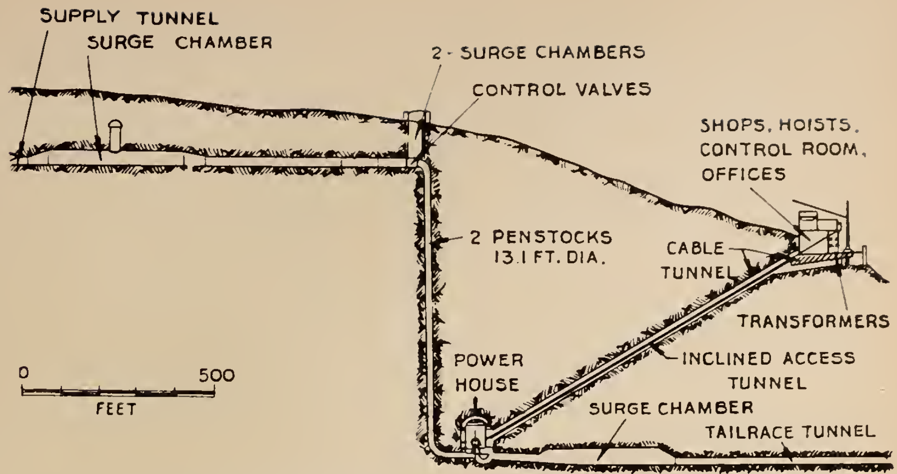


Fig. 16. General arrangement of Brommat underground power plant.

With a very few exceptions, underground factories in Germany, Japan and Italy were hurriedly located in existing caves, mines, quarries or tunnels, these being enlarged or altered as necessary to fit them for the new service, and without advance planning. Due to shortage of manpower, materials and equipment, desirable and necessary features, such as air conditioning, were often omitted. Many German and Japanese plants were subject to excessive dampness which caused rapid corrosion and deterioration of equipment, as well as discomfort and illness. The Japanese underground factories, in particular, have been reported as notoriously lacking in features conducive to worker efficiency, comfort and health.

On the other hand, underground factories in Sweden proved to be satisfactory, very largely due to the fact that proper consideration was given to ventilation and air conditioning, lighting and heating. Swedish workers are reported as liking the clean warm atmosphere of the underground factories, particularly during the long, dark winters. No special measures, such as sun-lamp treatments or special rest periods, were found necessary to maintain morale. Productivity proved to be as high as, if not higher than, that in surface plants. Employee turn-over was no greater than in ordinary factories, less than one per cent being reported as leaving due to location of the factory underground. Swedish industrialists were apparently pleasantly surprised to find how acceptable the underground factory conditions proved to their workers, as well as being economical.

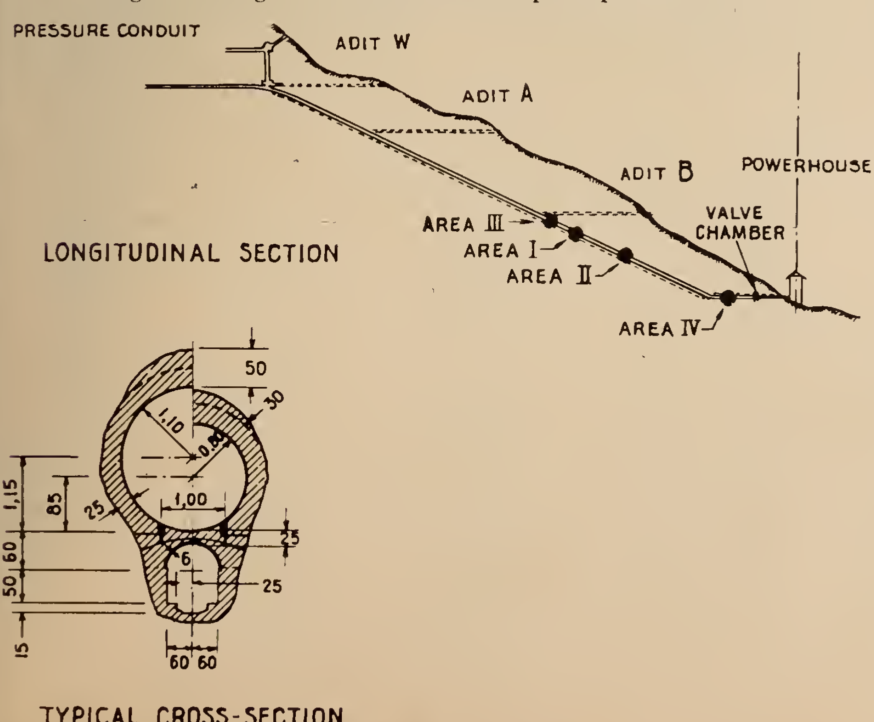
Failures

Pressure tunnels and conduits have been ruptured due to water hammer. It is less commonly known that several steel-lined pressure tunnels have been ruptured due to the inability of the surrounding rock to withstand the internal pressure.[10, 17]

Cases are known where ruptures have occured along fissures in the rock occasioning local concentrations of pressure and high resultant bending stresses in the liner.[10, 17]

The most notable failures were those at Gerlos, Austria, in 1945 and 1948. The steel-lined underground penstock serving the conventional Gerlos power plant was placed in service in August, 1945. On October 30th that year two failures along the penstock caused extensive damage. After repairing the damage and a single refilling, another similar accident of lesser severity occured. The plant was returned to service in March, 1948, but a fourth similar failure took place in September, 1948. Repairs were effected and the plant was back in operation December 22nd, 1948, since when it is understood to have operated without trouble arising from the penstock.[4, 5] Note Fig. 17.

Fig. 17. Underground Penstock for Gerlos power plant in Austria.



The penstock, inclined at an angle of about 27° to the horizontal, is some 4170 ft. long. It operates under a maximum head of 2035 ft. The internal diameter decreases from 7.22 ft. at the upper end to 5.25 ft. at the lower. Thickness of the liner varies from 0.472 in. to 1.20 in. Tensile strength of the steel is about 58,300 to 68,300 p.s.i. The penstock was designed to withstand full hydrostatic pressure without reaching the yield point of the steel. Shop and field joints were electrically welded and X-rayed. [4]

The penstock is emplaced in quartz phyllite and shale rocks, showing frequent transitions from compact to badly fractured schistose or argillaceous zones. The light to dark grey phyllite is intercalated with thin bands of limestone and dolomite. Some soft plastic zones were filled with fine greasy material. [4]

The four penstock failures involved extensive ruptures along lines parallel to the inspection and drainage gallery of 2.65 ft. width located under the penstock from which it was separated by a rather thin concrete masonry member. The failures were accompanied by erosion of substantial volumes of rock and flooding of the generating units. [4, 5]

All factors pertaining to the failures were closely investigated.[5] The evidence points to failure of the concrete sheath surrounding the liner with a strong presumption that failure occurred initially in the concrete masonry between the penstock and the inspection and drainage gallery. However, there is a very substantial volume of evidence linking brittle fracture of the steel with the failures.

Other Underground Power Plants

A 4375 h.p. underground diesel power plant was constructed in Hawaii during World War II. No particular difficulties were encountered with this station, from an operating point of view, although a diesel generating plant is inherently noisier than a hydro-electric power plant.

A 32,000 kw., 1482 p.s.i., 932° F. steam-turbine power plant was installed underground in Mannheim, Germany, and operated from July, 1941, to June, 1945, quite successfully. The Berne Electricity Co. built a 9,400 kw. underground steam-power plant at Engehalde near Berne. Although this is a standby plant, it has operated quite successfully. The French have built an underground steam power plant at Brest-Portzic with a capacity of 40,000 kw. in two units, since the war.

More recently the Stenungsund steam power station has been under construction in Sweden. Provision is made for two 140,000 kw. units to be completed in 1959 and 1960 respectively, with a third 200,000 kw. unit ready by 1961. The excavation provides for a fourth unit and provision is made for an additional two units. Though the first two units will burn oil only, the third will use either oil or coal, provision being made for transition to the latter. Steam temperature is 1000° F. and pressure 1050 p.s.i. for the first two units. Each boiler with its associated turbogenerator and transformer is placed in a separate chamber, the dimensions of which, for the first two units, are 410 ft. long, 80 ft. wide and 100 ft. high, excavated underground. Cooling water is carried through supply and discharge tunnels. Oil storage will be in unlined chambers underground.

Sweden is constructing a 75,000 kw. thermal capacity heavy-water-moderated nuclear reactor underground, near Vasteras. This plant will supply 250° F. hot water for heating dwellings and industries in the city. The reactor room, with dimensions of about 200 by 50 by 90 ft., the control room and the transformer room will be excavated from the rock underground, with the office facilities and storage rooms being located on the surface.

Typical Underground Power Schemes

With almost 300 underground hydro-electric power plants in service or under construction, it is difficult to select the most notable examples, given the wide range of location, geological settings, head, discharge, capacity and number of units involved, as well as date of construction. Table IV is a comparative tabulation of the head, number of units, installed capacity, type of waterwheel and setting (horizontal or vertical) for 18 of the world's leading underground plants. It will be noted the heads range from 244 ft. for Stornorrfors in Sweden to 2600 ft. for Kemano in Canada. The number of units runs from two, in several plants, to an ultimate 16 in Kemano. The minimum capacity is 61,600 h.p. in Japan's first plant, Sudagai, and the maximum the 2,400,000 h.p. for the complete Kemano scheme. With one exception the generating units are vertical, whether Francis or impulse types of turbines are used.

Table V furnishes a comparison of

Table IV—Head and Capacity of Notable Underground Hydro-Electric Power Plants

Plant	*Country*	*Head ft.*	*No. of Units*	*Installed Capacity hp*	*Type of Waterwheel*	*Horizontal or Vertical*
Bersimis I	Canada	875	8	1,200,000	Francis	V
Brommat	France	855	6	240,000	Francis	V
Chute-des-Passes	Canada	640	5	1,000,000	Francis	V
Cubatao	Brazil	2362	6	528,000	Impulse	V
Fionnay	Switzerland	1555	3	216,000	Francis	V
Haas	U.S.A.	2448	2	184,000	Impulse	V
Harspranget	Sweden	353	3		Francis	V
			4	508,000	Francis	V
Innertkirchen	Switzerland	2200	5	280,000	Impulse	V
Kemano	Canada	2600	8(1)	1,200,000(1)	Impulse	V
			16(2)	2,400,000(2)	Impulse	V
Montpezat	France	2080	2	162,000	Double overhung Impulse	H
Nilo Pecanha	Brazil	1130	6	442,000	Francis	V
Randens (Isère-Arc)	France	502	4	180,000	Francis	V
Santa Giustina	Italy	600	3	142,500	Francis	V
Snowy Mountains-T1	Australia	1100	4	538,000	Francis	V
Soverzene	Italy	870	4	290,000	Francis	V
Stornorrfors	Sweden	244	4	712,000	Francis	V
Sudagai	Japan	274	2	61,600	Francis	V
Vinstra	Norway	1450	4	240,000	Francis	V

(1) First half of development.
(2) Second half of development.

Plant	Country	Geological Setting(a)	Transformer Location	Unit Valve Location
Bersimis I	Canada	Paragneisses, massive granites	Surface	P.H. chamber (b)
Brommat	France	Granite	Surface	P.H. chamber
Chute-des-Passes	Canada	Paragneiss	Surface	P.H. chamber
Cubatao	Brazil	Granitic gneiss	P.H. chamber	Separate valve chamber
Fionnay	Switzerland	Calcareous schists	Surface	Separate valve chamber
Haas	U.S.A.	Granite	Surface	P.H. chamber
Harspranget	Sweden		Transformer chamber	
Innertkirchen	Switzerland	Granite and gneiss	P.H. chamber	Separate valve chamber
Kemano	Canada	Granodiorite with small feldspar, aplite, lampophyre and diorite dykes	P.H. chamber	Separate valve chamber
Montpezat	France	Granite	Surface	
Nilo Pecanha	Brazil	Gneiss, kaolinized zones	P.H. chamber	P.H. chamber
Randens (Isère-Arc)	France	Mica schist	Transformer chamber	P.H. chamber
Santa Giustina	Italy	Marls	Surface	P.H. chamber
Snowy Mountains Tl	Australia	Granitic gneiss and granite, extensively jointed	Transformer chamber	P.H. chamber
Soverzene	Italy		Transformer chamber	P.H. chamber
Stornorrfors	Sweden	Granite and gneiss	Transformer chamber	
Sudagai	Japan	Coarse-grained granite	Surface	P.H. chamber
Vinstra	Norway	Granite	Transformer chamber	P.H. chamber

(a) For penstocks
(b) P.H. chamber . . powerhouse chamber

Table V—General Features of some Underground Hydro-Electric Power Plants

the geological settings, step-up transformer and unit valve locations for the same plants as Table IV. The wide variety of geological conditions is noteworthy.

Table VI is a comparison, for most of the plants included in Tables IV and V, of the volume of excavation in the powerhouse chamber per kilowatt of installed capacity. It will be noted only 25 percent of the plants compared run over 0.35 cu.yd./kw. Somewhat over a third involve less than 0.25 cu.yd./kw.

A most important element in underground hydro-electric power schemes is the penstock or penstocks, because these facilities ordinarily represent a substantial percentage of the total construction cost, particularly in high-head plants. Table VII indicates the pertinent features for many of the world's notable underground plants.

Table VIII indicates the type of steel, with its ultimate strength and yield point, used in a number of the outstanding underground power plant penstocks.

By way of contrast and as an indication of possible savings in steel necessary for the lining of underground penstocks, attention is drawn in Table IX to three penstocks designed by Marinoni. These are characterized by linings of corrugated steel plates less than 1/10 in. thick over ordinary concrete sheaths. The steel lining acts only as a watertight membrane, the hydrostatic load due to the water in the penstock being transmitted to the surrounding rock. During thirty years of service there have been various incidents involving failure of the steel linings, particularly at Mese, due to collapse arising from the external pressure. These have been quickly repaired. The Mese liner has also been ruptured due to internal pressure.[10, 17]

The TI power station of the Snowy Mountains scheme in Australia is notable as the first major underground plant in which rock bolts have been used, in a planned manner, to form a diaphragm of material somewhat less in thickness than the length of the rock bolt, at or immediately behind the free surfaces of the power chamber excavation, which diaphragm is utilised as a structural member of ascertainable properties and behaviour.[15] Fig. 18 shows the general layout of the T1 plant while Fig. 19 illustrates a cross-section through power plant itself.

Table VI—Excavation Volumes for Underground Hydro-Electric Power Plants

Plant	Country	Year of Initial Service	Total Capacity in kw.	Powerhouse Excavation cu.yd.	Excavation for Transformer and/or Valve Chambers cu.yd.	Powerhouse Excavation cu.yd./kw.
Brommat	France	1932	186,000	60,000	16,000	0.32
Cubatao	Brazil	—	465,000	122,800	8,600	0.288
Fionnay	Switzerland	—	127,500	27,000	1,800	0.21
Haas	U.S.A.	1958	135,000	29,000	—	0.21
Harspranget	Sweden	1951	288,000(a)	63,300	30,000	0.22(a)
			380,000(b)	79,000	—	0.206(b)
Innertkirchen	Switzerland	1942	210,000	59,000	20,000	0.28
Kemano	Canada	1954	835,000(a)	290,000(a)	20,948(a)	0.347(a)
			1,670,000(b)	473,000(b)	—	0.284(b)
Montpezat	France	1954	116,000	26,300	—	0.226
Nilo Pecanha	Brazil	1953	355,000	98,000	—	0.274
Randens (Isère-Arc)	France	1953	135,000	68,000	—	0.50
Santa Giustina	Italy	1951	108,000	40,000	—	0.37
Soverzene	Italy	1948	220,000	85,500	16,500	0.390
Stornorrfors	Sweden	—	375,000	—	—	0.27
Sudagai	Japan	1955	46,000	28,100	—	0.61
Vinstra	Norway	—	180,000	30,000	8,170	0.167

(a) First stage.
(b) Second stage.

Plant	Gross Head in ft.	Internal Dia., in ft.	Rock	No. of Pen-stocks	Discharge per Pen-stock in c.f.s.	Angle with horizontal in degrees	Thickness of steel, in in.	Turbine H.P. per Penstock
Bersimis I	875	10.0–7.75	Paragneiss, granite	8	1,837(1)	Horizontal	1.06–2.06	—
Brommat	855	13.12–9.84–8.53	Granite	3	—	Vertical	0.47–1.93	—
Chute-des-Passes	640	15–11	Paragneiss	5	—	Practically Horizontal	1.50–2.0	—
Cubatao	2362	10.66	Granitic gneiss	—	2,650	42	0.91	—
Fionnay	1555	7.9	Calcareous schists	1	812	38.7	0.79	—
Haas	2448	6.83(2)	Granite	1	760	65	2.00	184,000
Innertkirchen	2200	8.50–7.87	Granite and gneiss	1	1,410	31.7–7.0	0.79	325,000
Kemano	2600	11.0	Granodiorite	4(3)	2,400(4)	48	0.563–1.938	600,000
Nilo Pecanha	1130	20.01	Gneiss, kaolinized zones	—	4,415	42	0.47–1.18	—
Randens (Isère-Arc)	502	12.14	Mica schist	2	1,770	Vertical	0.63	90,000
Snowy Mountains T1	1100	12.00	Granitic gneiss and granite, extensively jointed	2	4,530	Vertical	0.625–1.625	270,000
Soverzene	870	8.38	—	2	705	71.6	Prestressed Concrete	—
Stornorrfors	244	26	—	4	7,000	Vertical	—	178,000
Sudagai	274	12.14–8.69	Granite	2	1,150	Vertical	—	—

(1) Strictly speaking these figures relate to one of eight short branches of the main supply tunnel.
(2) Except for wye and short unit branch.
(3) Ultimate.
(4) Maximum discharge.

Table VII—Pertinent Features of Embedded Steel-Lined Penstocks for Underground Power Plants

The plant was emplaced in a formation of granitic gneiss and granite, described by Lang[15] in the following terms:—

"The granite occurs in sheets 100 to 300 ft. thick intrusive into the gneiss. These sheets strike nearly east-west and dip towards the south at 40° to 50°. Their contacts with the gneiss show embankments, tongues and veins of granite in the gneiss. Several nearly vertical dykes of dolerite and basalt occur intrusive into both granite and gneiss, and vary in width from a few inches up to 40 ft. With the exception of one very thin basalt dyke which passes across the north eastern corner of the machine hall, none of the dykes intersect the Power Station."

The formation was found to be extensively jointed, with three principal directions of jointing, in a not very regular pattern, described by Lang[15] as follows (see Fig. 20).

"(a) Joints striking N 40° to 60° E, nearly parallel to the long axis of the machine hall, and dipping 25° to 35° upstream. A zone of joints in this direction persisted over the full length of the machine hall roof, varying from one to several major joints in width ½ to 1 in. of crushed rock and a little clay in the granite, to a zone 5 to 10 ft. wide of close jointing (2 to 6 in. spacing) in the granitic gneiss.

"(b) Joints striking N 30° E making an angle of about 30° to the long axis of the machine hall, with dips varying from 65° W to 80° E. In one localized zone these joints in both the granitic gneiss and granite were closely spaced, clay coated and persistent.

"(c) Joints striking N 130° E, nearly at right angles to the machine hall, with an almost vertical dip. Certain joints in this direction spaced 40 to 80 feet apart were very persistent, open up to ¼ in. and limonite stained. All the main water inflows occurred along these joints.

"The two rock types exhibited characteristic differences in the general spacing of the joints and the nature of the joint surfaces.

"The joint spacing in granitic gneiss was usually between 6 in. and 2 ft. The joint surfaces were usually smooth and slickensided and dark green in colour due to thin coatings of chlorite. Clay coatings were not common and most joints were tightly closed. Because of the nature of the joint surfaces it was common in the excavations for the granitic gneiss to break to the natural joint planes rather than break across the rock resulting in angular surfaces and local small overbreak in many places. The joint spacing in granite was variable but was generally in the range of 1 to 5 ft. The more closely jointed zones occurred irregularly.

"Slickensided joints were not so common as in the gneiss. The joints were

Table VIII—Details of Steel used for Lining Embedded Penstocks

Plant	Type of Steel	Ultimate Strength p.s.i.	Yield Point p.s.i.
Bersimis I	ASTM A201, grade B, firebox quality.		
Chute-des-Passes	ASTM A201, grade B, firebox quality, fine grain practice.		
Cubatao		75,400	42,000
Fionnay	(Header) Cr-Cu steel quality Dillinox 50.	71,100–85,300	
Haas	ASTM A242, Mayori R, Kaisalloy or Tri-Ten quality.	67,000	47,000
Innertkirchen		61,100–68,200	
Kemano	Less than 1 in. thick, ASTM A285, grade B, firebox quality. One inch and greater thickness, ASTM A201, grade A, firebox quality.		
Nilo Pecanha		70,400	42,000

Table IX—Details of Embedded Penstocks with Minimum Steel Lining

Plant	Pallanzeno	Rovesca	Mese
Country	Italy	Italy	Italy
Date placed in service	1926	1926	1926
Gross head, ft.	1730	2360	2490
Diameter of penstock, ft.	6 to 5	4	6
No. of penstocks	1	1	1
Discharge, c.f.s.	297	106	—
Slope, angle with horizontal, degrees	35	7–35	35
Rock	Gneiss, mediocre	Schists and gneiss	Gneiss, mediocre
Tensile stress in rock sheath, p.s.i.	750	1,025	1,075

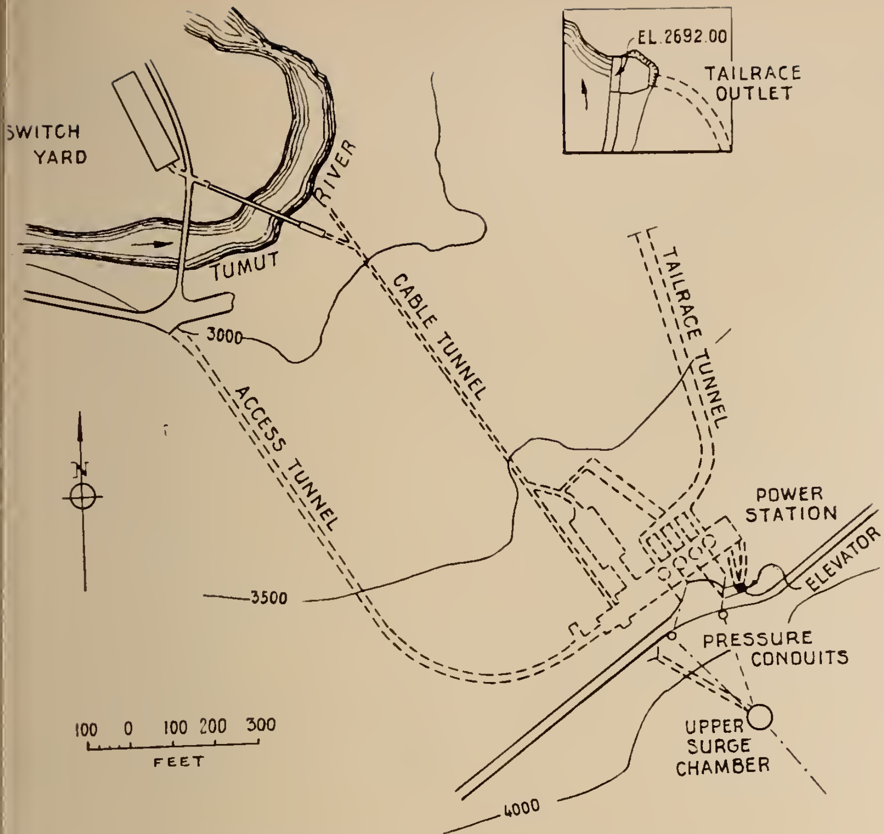


Fig. 18. General layout of the Snowy Mountains, T1 Power station.

mostly tightly closed with the exception of certain joints with strike N 130° E already mentioned which were open, limonite stained, and water bearing. Because of the generally tight nature of the joints in the granite, it was found that breakage of the rock often occurred along new fracture surfaces rather than along natural joints.

"Another geological structure of importance was a nearly horizontal persistent zone of close fracturing, a few inches wide with heavy limonite staining along the fractures which occurred throughout the machine hall and transformer hall area [(d) Fig. 20]. It was located a short distance above the portals of the penstock tunnels on the upstream wall, and above the tailrace tunnels on the downstream wall."

CONCLUSIONS

The following significant factors relative to the design, construction, operation and maintenance of underground power plants have been developed in the paper:—

1. Some 300 hydro-electric plants are in service or under construction, with an installed capacity of about 31,000,000 kw.
2. About the same capacity is in the planning stage.
3. No limitations due to climate, location, head, flow or capacity exist, in development in underground plants.
4. Major steam and atomic power plants have been, or are being, built

(Continued on page 67)

Fig 19. Cross-section through T1 power station, Snowy Mountains Scheme, Australia.

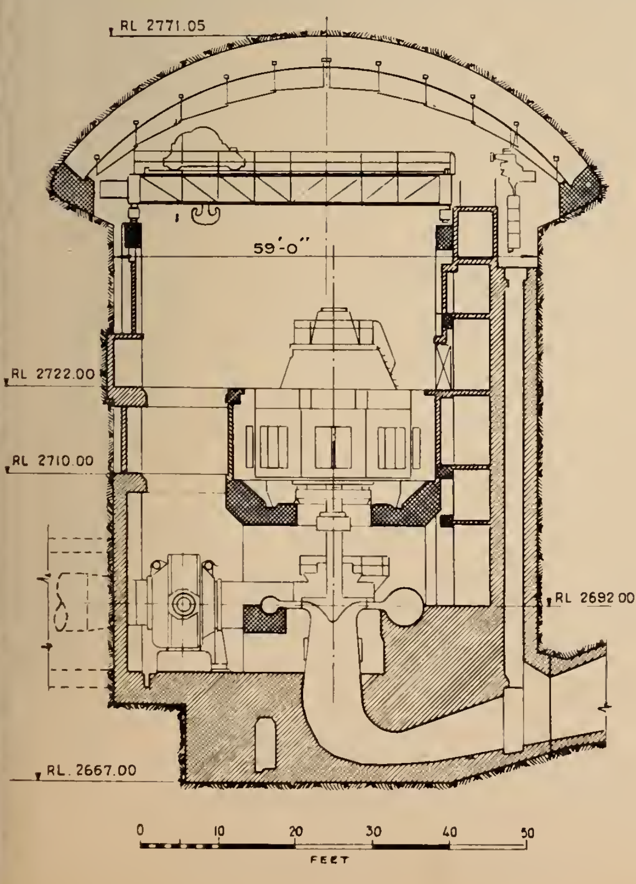
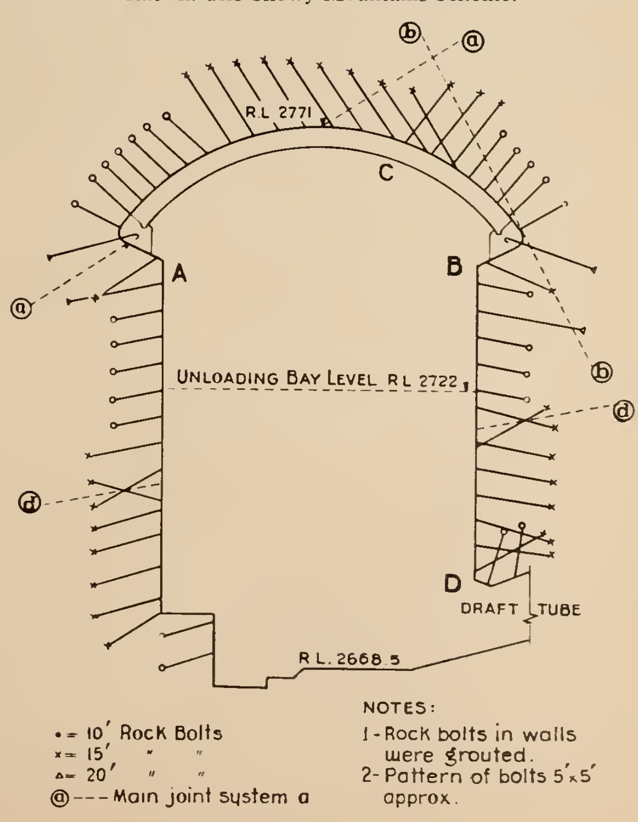


Fig. 20. Rock bolting in generator chamber of T1 power station. The Snowy Mountains Scheme.



PLASTIC BEHAVIOUR OF STEEL FRAMES

Experimental Verification of Theory

J. W. Dolphin, *Professor and Head of Department of Civil Engineering, Royal Military College, Kingston.*

Although three structures designed using the Plastic Theory are in use in Canada today, little evidence is available illustrating the behaviour of members and structures loaded to collapse. A series of tests were made on beams and frames of standard rolled sections and the results which include the verification of basic principles are presented.

As part of a short course dealing with the use of the Plastic Theory in structural design, several tests were made on full sized beams and frames in order to show the relationship between the theory and the behaviour of full sized members. The tests were arranged to show:

(a) The moment-curvature relationship.
(b) The fundamental concept of moment redistribution.
(c) The correspondence between predicted and experimental loads and collapsed forms.
(d) The effects of shear and instability.

Moment Curvature Relationship

The basic concepts of the Plastic Theory have been presented elsewhere.[1, 2] The moment curvature relationship developed in that theory is shown in Figure 1. Also plotted in this figure is a curve of the experimental values found during the test of a 10 WF 25, eleven feet long, loaded at the third points in pure bending.

Residual stresses in the beam caused local yielding and resulted in a divergence from the theoretical curve. Full plastic moment was realized however and the flat top characteristic of the M-ϕ curve was obtained. Since the Plastic Theory is based, among other things, on the assumption that a material will satisfy the theoretical M-ϕ relationship, this demonstration is graphic proof that structural shapes may be used in Plastic Design.

Redistribution of Bending Moment

The redistribution of bending moment in a continuous structure with portions within the plastic range is one of the most important basic concepts of the plastic theory. Once yielding occurs in one portion of a statically indeterminate structure, additional loads result in other points accepting a greater share of the moment. This continues until a sufficient number of points within the structure have yielded (developed "plastic hinges") so that the structure becomes a mechanism and can no longer support additional load.

An 8 B 13 beam, span 12 feet, was rigidly fixed at one end and simply supported at the other. It was loaded to collapse to show the redistribution of moments, the loading arrangement being as shown in Figure 2. The curves of this figure show:

(a) The typical load deflection curve.
(b) That the moment at *A* did not reach full plastic moment because of the high shear at the point. This was partially offset by strain hardening at *A* caused by the large rotation at this point.
(c) Even though some rotation of the beam axis at *A* did occur, the moment at *B* reached full plastic moment and failure of the structure occurred at a value only slightly higher than the predicted 29,300 lb.

From this test it can be seen that the moment was eventually distributed as predicted and that the Plastic Theory can be applied to indeterminate structures.

Simple Frames

In order to prove the application of the plastic theory to frames, six small frames and two large portal frames were tested to collapse. The small frames were fabricated at 4 B 13 sections to the dimensions shown in Figure 3. Two frames each were tested as follows:

(a) single vertical load, midspan on the beam
(b) single horizontal load, at the top of the column
(c) vertical and horizontal loads combined

Figure 3 shows the results of the tests on one of the frames tested with horizontal and vertical loads. The formation of plastic hinges in the frame as the loading increased is clearly shown by the change in slope of the curves. The failure of the frame at a value only slightly higher than the predicted collapse load shows again that the plastic theory can be applied to frames.

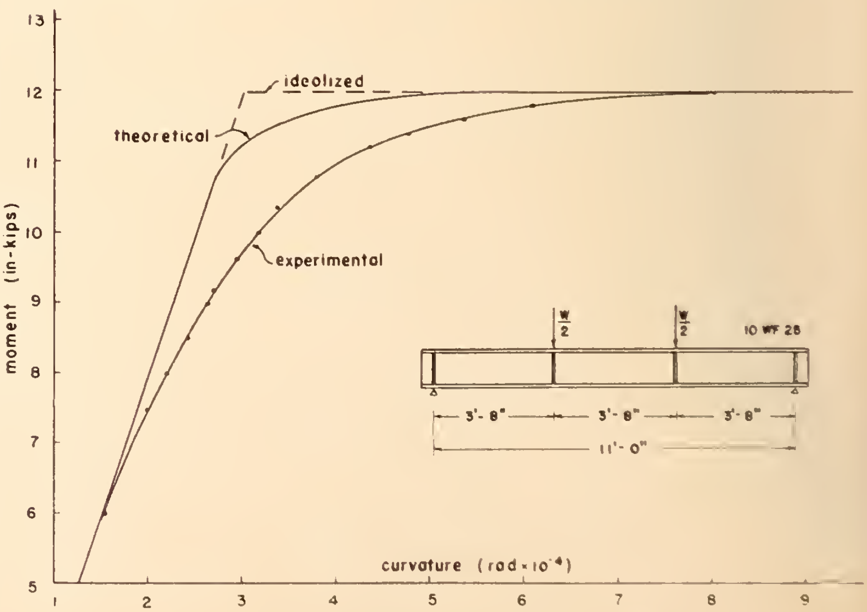


FIG. 1 MOMENT - CURVATURE RELATION

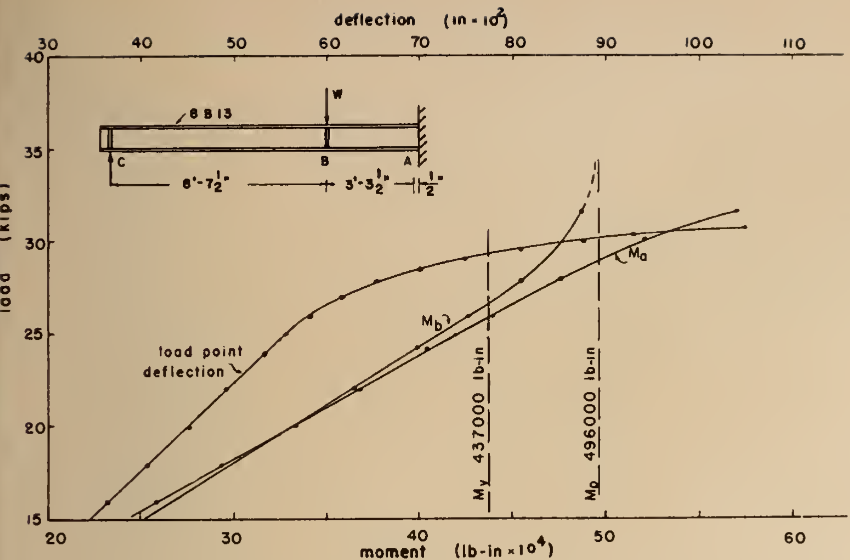


FIG · 2

The results of the other tests on the small frames showed almost identical results. It is interesting to note here that 20,000 p.s.i. at the most stressed point would have resulted in *W* being restricted to approximately 5*K* whereas the factor of safety usually used in Plastic Design of 1.88 would have given a working load of 9.2*k*. This value is still below the load at which yield first occurred anywhere in the frame and permits an additional 84 per cent load to be carried without distortion or fear of collapse.

The large portal frame which was tested is shown in Figure 4 and the loading arrangement in Figure 5. The result of the test of one frame is plotted and again shows the same applicability of the Plastic Design method. The first deviation from elastic conditions appeared at 23 kips when the curve of the vertical deflection at the ridge ceased to be linear. Maximum permissible design load (governed by 26,600 p.s.i. at *E*) occurred at a value of *W* of approximately 6 kips which indicates a factor of safety of over 1.9. The factor of safety of 1.41 intended by the Plastic Theory when wind forces are present was slightly exceeded leaving a safe margin before first yield in the structure.

The theory of failure of the small frames and of portal frames is discussed in other publications.[1, 2]

Shear, Instability and Connections

The effect of shear on plastic behaviour is complex but is essentially a reduction in plastic bending capacity due to yielding of the web under combined stresses. This phenomenon is discussed and formulae derived in references 2 and 3 but it should be noted that the formulae do not allow for strain hardening which accompanies yielding of this type. Tests on a 10 WF 25 beam of 8 foot span loaded equally at points 21 inches from the reactions showed less reduction in flexural strength than was predicted. The tests did serve to show however, that formulae designed to predict failure when shear is present are satisfactory.

Lateral instability of a 10 WF 21 loaded equally at points 28 inches from the ends of a 10 foot span and unsupported laterally, failed when the load was only 65 percent of the estimated plastic collapse load. It was definitely shown that if large rotations are to be permitted to occur, lateral movement must be prevented. In practice, points of possible hinge formation are braced laterally as in conventional lateral design.

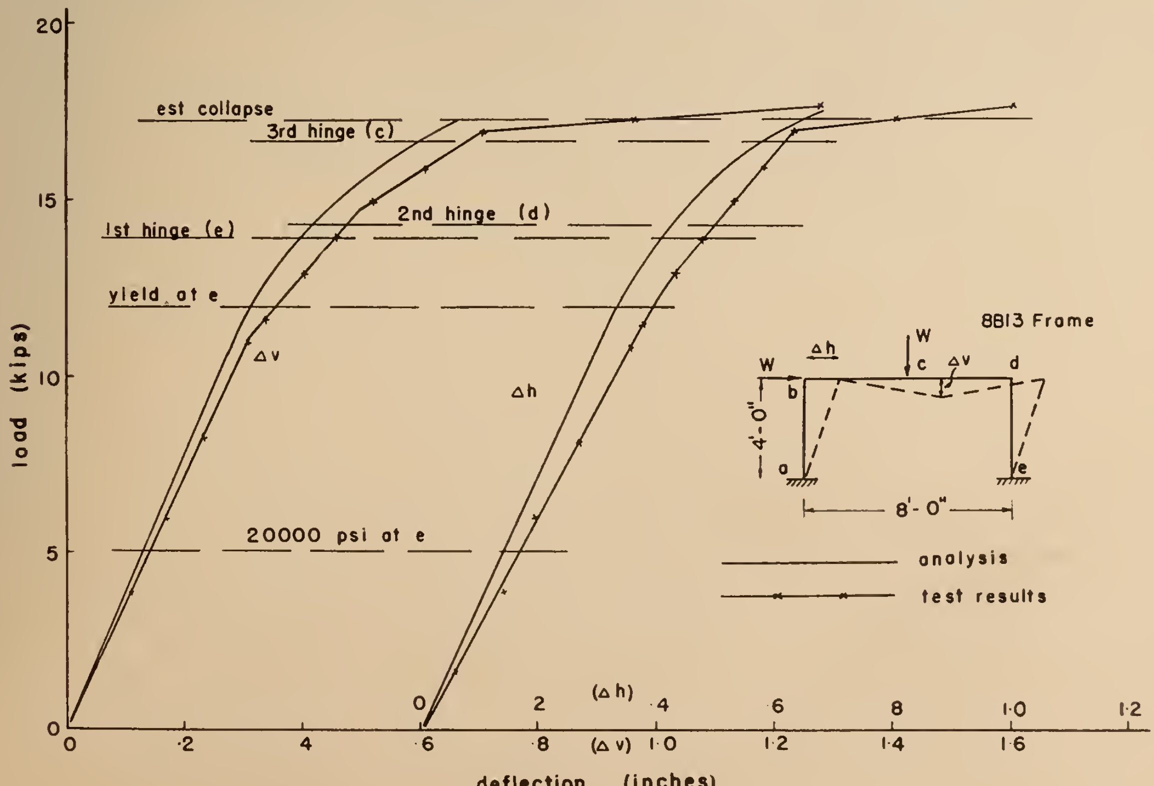
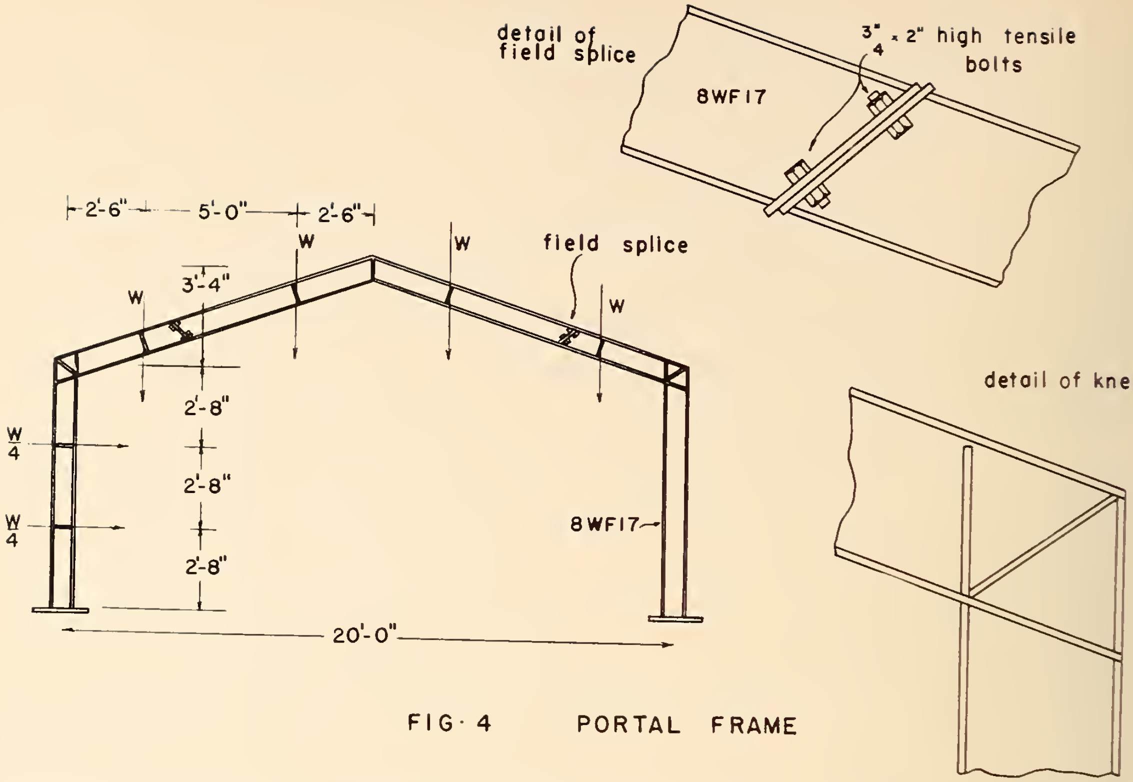


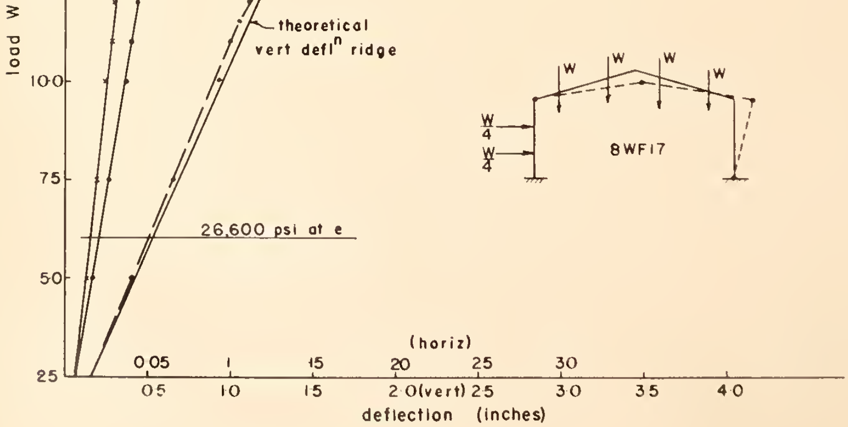
FIG · 3



FIG· 4 PORTAL FRAME

Local deformations sometimes occur in WF and I sections when large strains occur. For full plastic development of a hinge resulting in proper moment redistribution, large strains are required. To test this condition a 6 WF 15.5 beam of 10 foot span was loaded at its third points and full plastic resistance attained without flange buckling. The ratio of flange breadth to flange thickness for this beam is over 22 while the recommended[4] maximum ratio is 17. In certain other tests, particularly in the portal frame test, flange buckling did occur, but not until after the hinge had been formed so that no reduction in capacity occurred.

Structures designed to take advantage of moment redistribution must be continuous. Frequently a knee joint is required. The combination of bending and shear at this joint usually requires that the web be reinforced and simple rules have now been formulated for these joints.[5, 6]



FIG· 5

Tests were made on two knee joints using 6 B 12 sections. One knee was unreinforced, the other was reinforced in the web. Without web reinforcement the joint carried only 79 percent of the theoretical capacity while the reinforced joint carried 99 per cent.

Conclusion

These tests demonstrated beyond doubt that the Plastic Theory can be applied to large size frames built up of rolled structural shapes and that the use of higher working loads will, in most cases, result in more efficient use of the material with a consequent saving in cost while not causing permanent distortions.

Further details of these tests and photographs of deformed members may be seen in another paper on this subject.[7]

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The Cost Of Housing

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Paper presented to the Toronto Branch of the Engineering Institute of Canada, 10th April 1958

THE COST OF HOUSING is an important public question in Canada today. It is the subject of many discussions, both public and private. The man in the street is vitally concerned with housing, if only because of the difficulty that so many people have in finding the sort of homes they need. All too many citizens are continually concerned with the problem of financing the shelter they use. Almost all Canadians indulge in dreams, at some time or other, if not of castles in the air at least of a modern house unencumbered by mortgage.

Not only is housing a matter of concern to the man in the street, but it now occupies a dominant position in the national economy. The value of housing built in Canada each year is approximately equivalent to the total cost of all major heavy engineering construction. When thought is given to the many miles of roads, air fields, and the great dams and power plants that are under construction in Canada today, this one fact illustrates vividly the national importance of housing. This importance has been made clear in the recent report of the Royal Commission on Canada's Economic Prospects (the Gordon Commission) which estimates that between 1956 and 1980 Canada will spend on housing forty-three billion, seven-hundred million dollars, based on the 1955 value of the dollar.

It is not inappropriate, therefore, for the Division of Building Research of the National Research Council to regard research into the technical aspects of housing as one of its greatest responsibilities. All of its studies in this field are carried out in close association with Central Mortgage and Housing Corporation which it serves as a research wing on all aspects of technical research. Both the Corporation and the Division have the pleasure of co-operating with the National House Builders Association, through its Research Committee. In all questions affecting the use of wood in house construction, the Division correspondingly works closely with the Forest Products Laboratories of Canada.

In the many discussions on housing in which members of the Division of Building Research staff take part, often in association with members of the staffs of the other organizations mentioned, the cost of housing is paramount. Over the years it has become clear that there are many misconceptions in the public mind about this vital aspect of housing. It is not going too far to say that the Division knows of no technical question on which there is so much uninformed thinking in Canada today as the cost of housing. Correspondingly there are few things that are criticized more, in connection with housing, than the high costs that have to be met in the provision of shelter in Canada in 1958. There is, accordingly, a desperate and widespread search for some solution to the problem of "low cost housing". The Division also encounters remarkable misconceptions regarding the relative position of the cost of renting shelter and of purchasing it. There are probably more misconceptions about rentals than about the cost of new housing.

Comparisons are repeatedly made, in discussion between the cost of new housing and of rentals today, and the corresponding costs in 1939. The Division hears all too much in the way of uninformed criticism about the effect of standards and codes upon the progress of housing, and even upon its cost. Statements are made, often by amateur "experts", about the fact that European countries can produce low-cost housing, and suggest that Canada should be able to do the same. Scandinavia is usually mentioned prominently in such discussions. Some speakers will even point to the United States, again in contrast with Canada, as a country in which low-cost housing is being achieved. There is a claim that if codes would permit the use of prefabrication (on the assumption that they impede this progress), in some mysterious way low-cost housing would immediately be available to Everyman. And in extreme cases speakers will wax eloquent about the wonderful possibilities which "plastics" present as the final answer to the great low-cost housing problem.

This paper is an attempt to cut through the fog of popular misconception on this problem and to make available in convenient form some of the facts of the situation upon which discussion must be based, if it is to be effective. It is, in fact, a simple application of what is sometimes called "engineering economics" to a subject with which engineers, most unfortunately, all too often have too little to do. In order to make the presentation as straightforward as possible, figures will be used for illustrative purposes only, discussion being confined rather to matters of principle. The objective will be to discover what is really meant by the cost of housing and, if this can readily be stated, to see in which directions reductions in current costs are possible.

The Cost Of New Houses

Confining discussion initially to the construction of individual single-family houses, which today make up the great majority of residences for Canadians and which represented 69% of all new home construction in 1957, what is really meant by the cost of such new housing? Many people think only of the cost of the structure itself or the amount that has to be paid to the builder. This, however, is only part of the cost. Table I shows a breakdown of the items which, together, must be considered in all proper considerations of the actual first cost, or capital cost, of a new house in Canada today. One small item which is persistently neglected is the interest upon capital which must be paid during the construction of a house until such time as the house is actually occupied.

Real Or Annual Cost

Perhaps the most difficult aspect of the entire question of housing costs is to gain general appreciation for the fact that the real cost of housing is not the first or capital cost, but is the annual cost. To engineers and others concerned with the economics of building, this is so obvious that it is almost a truism. Unfortunately, however, this appreciation of the importance of annual cost is restricted to a very narrow circle. It is only by proper consideration of annual costs that any true comparison of real housing costs can be made. Table II lists the items that must be considered in an assessment of the real or annual cost of a house in Canada today.

Some comment is required on the following items shown in Table II:

(*a*) This must be the interest, at the current interest rate for real estate loans, upon the *total* capital outlay for the house, i.e. upon the total of all the items in Table I, irrespective of what "down payment" has been paid in connection with a first mortgage.

(*b*) Payments for the anticipated *amortization* of the property must be included in realistic calculations of housing costs, if only because such payments must be made when houses are purchased under the National Housing Act. Further than this, however, it is only sound economics to allow for such payments. They represent the liquidating of the mortgage within a specified number of years from the time the house is completed, a period of up to thirty years under existing N.H.A. regulations. This means that, at the end of the mortgage period, a house will be free of debt and yet, if maintenance has been carried out effectively, the house will have a certain market value. This value represents what can best be expressed as "enforced savings".

It is easy to overlook the fact that exactly the same savings could have been achieved if the house owner had, for example, rented accommodation throughout the period of the mortgage and invested soundly exactly the same regular capital amounts as he has paid on his mortgage. What has tended to obscure this aspect of house purchase has been the steady devaluation of the dollar during recent years, the sale value of a house therefore increasing in the course of time instead of decreasing, as it does in real value. And since human nature is what it is, the enforced saving which the purchase of a house usually involves is, for most citizens, one of the few really effective ways of saving regularly.

(*c*) *Maintenance* costs for a house are all too often forgotten, especially in cost calculations made very shortly after a house has been occupied when everything is ship-shape and nothing obviously in need of repair. But over the effective life of a house, even when designed and built to the highest standards, maintenance costs must be incurred to cover the repair of ordinary wear and tear, the replacement of breakage, the repainting of painted surfaces, the maintenance of mechanical and electrical equipment in good order etc. Some of these individual items can be appreciable but long experience has shown that if total maintenance costs are averaged over the useful life of a house, an annual average cost can be obtained that may conveniently be expressed as a percentage of the total first cost of the house. For modern well-built Canadian houses, an average annual sum of 1¼% is the minimum that can be safely allowed.

As with all averages, there can be substantial deviations from the figure suggested. For example, maintenance of the ordinary Canadian house involves painting at least a part of the

Table I

Items Involved In House Purchase

(a) (Land
    (Services
(b) Structure
    (Survey
(c) (Legal fee
    (Commission to realtor
(d) Interest during construction

Table II

Breakdown of Annual Cost of Housing

(a) Interest on capital
(b) Amortization
(c) Maintenance
(d) Taxes
(e) Operation
    Heating
    Light and power
    Water
(f) Insurance
(g) Transportation

exterior of the structure. If this costs, say, $60 per year ($180 every three years), it can readily be seen that, with an interest rate of 6%, this annual payment is the equivalent of $1,000 added to the capital cost of the house. If a satisfactory exterior finish which does not require any painting can be obtained for less than $1,000, then there exists economic justification for changing the design to include this finish, although there may sometimes be aesthetic or other personal objections to such a course. Correspondingly, taxes may be higher if the exterior finish of a house is improved.

(*d*) Little need be said about *taxes,* as a component part of the real cost of housing, since they are generally so recognized. It is sometimes necessary, however, to point out that it is this item which must include the financial allowances for new schools, new hospitals, new fire and police services and the many other necessary civic provisions for new housing areas.

(*e*) Costs of *operation* of a house are well recognized household expenses; that they must be considered in determining the true cost of housing will be evident when it is recalled that rents may or may not include the four items listed (heating, light, power, and water) so that all must be included in any comparisons that are to be valid. Further, the cost of house heating is directly related to the expenditure upon insulation. There are available helpful papers which enable the economic thickness of insulation to be determined for any locality in Canada, with varying prices of insulation and fuel, there being for any combination of these prices and a fixed heating load a thickness of insulation beyond which it does not "pay" to go in increased capital expenditure.

(*f*) The cost of *insurance* upon a house, for possible loss due to fire and damage due to "Acts of God", is not only an essential annual charge against a house when so required in connection with the issue of a mortgage, but is also a more than desirable expenditure even without this imperative.

(*g*) The inclusion of the cost of *transportation* as a part of the real or annual cost of housing may at first sight be surprising. It is certainly a hidden cost, or is perhaps more accurately described as the element of housing cost usually neglected, if indeed it is even recognized. The essential character of this item, if housing costs are to be realistically assessed and equitably compared, is shown as soon as it is remembered that in practically all Canadian cities new housing developments are located on the outer fringes of the existing built-up areas, thus being removed by steadily increasing distances from existing industrial and commercial office areas.

There are, of course, new industries also being built on the peripheries of cities but in general the steadily increasing distances to be travelled by new householders, as the scramble for relatively low cost building lots continues, cannot be denied. Public transportation may be used, in which case the cost is clear cut and easily recognized, but even when private automobiles are used, the cost is still there, even though it may not be so generally recognized or acknowledged. To all this should really be added the value of this time wasted in travelling, beyond a certain minimum that will always be necessary.

An Example Of Annual Housing Costs

Against the background provided by these explanatory notes, it may be useful to illustrate the discussion with a typical numerical example. This is shown in Table III, a computation based on existing rates and interest charges, applied to a capital investment of $20,000. This sum may be broken down into $15,000 as the cost of the structure, and $5,000 for the land, services and all other capital items shown in Table I.

Table III

Example of Annual Housing Costs

	Annual Amount	Percentage of Total
Interest on capital at 6%	$ 1200	50
Amortization charges, based on 25 years, compounded semi-annually	335	14
Maintenance at 1¼%	250	10
Taxes (at least . . .)	300	13
Insurance	35	1
Operation — heating and water	180	8
— light and power	100	4
Total excluding transportation	$ 2400	100

Some of the figures suggested might be criticized as being too low; they cannot be regarded as unreasonable. Accordingly, it is significant that the total annual payment is the equivalent of $200 per month. This is one per cent of the total invested capital. Older readers will perhaps remember, from the days when renting accommodation was not as uncommon in Canada as it is today, that a generally accepted rough and ready rule for calculated rentals was precisely the figure arrived at (with no preconceived ideas) in the above calculation—one per cent of the total capital cost per month. It is the annual cost shown in the Table that should be compared with annual rental charges. And it is rather more than surprising to find how many Canadian citizens have no idea at all of the rental they would have to pay to obtain accommodation equivalent to the houses in which they live.

It may be objected that the total annual cost shown in Table III includes the "enforced saving" in the amortization item, an objection that is well taken. But this sum is only $335 per year ($28 per month), so that if it is completely deducted (a questionable procedure) the over-all picture is still not substantially changed, the annual cost of the $20,000 property still exceeding $2,000 without including any transportation costs.

Another objection to such figures as those just presented is that many Canadians build their own homes, at least in part, again an objection often well founded. But the labour of the owner has some value, if only as the equivalent of the labour saved in the house-building operation. This will be little more than "common labour" in most cases, skilled tradesmen having usually to be employed for all specialist work. As an extreme case (and anyone who has participated in house building while performing his regular daily job will be the first to admit that it is an extreme case) consider the work of a man who spends 20 hours every week at his house-building "hobby" for 50 weeks of the year, long enough to include the usual duration of the construction of one house. This would be a total of 1,000 hours which would be worth, at $1.50 an hour, a total of $1500 or just 10 per cent of the total cost of such a typical house as used for an example in Table III. The corresponding reduction in annual cost would be a maximum of $115 (or 4.8%) but only if the amortization item is neglected. Admittedly these figures make no allowance for the personal satisfaction that self-building gives but even this reaction should not be allowed to obscure the basic economics of the cost of housing.

The percentages included in Table III are worthy of note. Approximately two-thirds of the total annual cost of housing is in the first two items, an amount arrived at by combining the total capital cost with a given interest rate. The remaining third is made up of items that do not depend directly upon the current interest rate for money and items which, if determined as has been suggested, are almost fixed amounts, capable of little change. Any appreciable saving in the real cost of housing must, therefore, come from a reduction in capital cost or in interest rate, or from an increase in the amortization period. Of these three components, the third is almost negligible as compared to the other two; there is also little probability of any substantial increase in amortization periods for Canadian houses in the immediate future. In considering possibilities for reducing the cost of housing, attention must therefore be concentrated upon interest rates as well as capital costs.

A Note On Transportation Costs And Housing

It is only with the development of post-war "urban sprawl" and the concurrent increase in the ownership and use of private automobiles, that the cost of transportation has loomed so large in the housing picture. Transit authorities are all too well aware of the changing pattern of the urban transportation picture, possibly the most serious aspect of which is that as the areas to be served by urban transportation facilities have increased, so also has the use of private automobiles. In consequence, while passenger volume has often dropped, route mileage has had to be increased. So serious is this that some Canadian municipalities are facing the prospect of subsidizing their local transportation systems. When this has to be done, transportation costs will be partially reflected in municipal taxes in addition to the direct costs involved which are obvious, even if usually neglected, in discussions of housing costs.

Assume that in order to obtain a building lot at "reasonable" cost, a prospective householder has to buy land ten miles away from his place of work and that he works the usual five-day week. Table IV shows the transportation costs involved, using various means of transport and minimum mileage rates. It will be seen that, even with the minimum figures used, at least $10 per month must be included in any estimate of housing cost (and corresponding figures for other housing proposals), if realistic comparisons are to be made between various alternatives. It may usefully be noted that since the cost of the house structure will be approximately the same within any one municipal area, the extra cost of transportation can properly be equated against the decrease in the cost of land and services with increasing distance from the civic centre (a decrease to which there is, of course, a limit).

$125 per year represents, at 6% interest, a capital amount of over $2,000 which therefore represents the absolute minimum difference in the cost of a building lot to justify the selection of a location ten miles from place of work instead of a location adjacent to it, if available, such that no transportation cost would be involved.

A Further Look At Capital Costs

If reference be made again to Table I it will be noted that the only cost over which a prospective householder has any control is the cost of the structure. The cost of land will be determined by land-market conditions for the area in which he wishes to build, a matter to be referred to again later. The cost to him of the necessary services will be determined by the actual installation costs, either by municipal authority or the land developing agency. Land survey costs are based on fixed professional charges. Legal and realtor's fees are based on the cost of the property at percentages fixed for every locality. Interest during construction will depend on the duration of the construction period and current interest rates.

What of the cost of the house itself? For a typical Canadian house of today, the total cost can be broken down, roughly, into:

Materials	45%
Labour	45%
Overhead and Profit	10%
Total	100%

Some readers will remember the old saying that "one third of the cost of a house goes to the local lumber yard", a rough and ready guide that agrees with the suggested breakdown of costs.

For the conventional type of modern house, containing what the "average Canadian" today demands, there can be little saving in the cost of materials, if purchased through the usual sales channels. Any appreciable savings can, therefore, only come from a more efficient use of labour such as by the use of prefabrication. Canadian house building practice, however, is not unduly inefficient; on the contrary, the operation of most well established builders is reasonably efficient; it has to be, to avoid the inevitable consequence of competition. Big savings in labour costs, for conventional construction, are not therefore to be expected. Even if a saving of 10% could be effected, this would mean only a saving of 4.5% on the total cost of the structure, and certainly not more than 3% on the total capital expenditure.

Do Standards Affect Costs?

When those who are concerned about the cost of housing first encounter figures such as those just cited, an almost immediate reaction is that they do not tell the true story "since building codes (or standards) interfere with any *real* reduction in costs." What are the facts?

On the technical side, most of the housing built in Canada since the war has been under the aegis of Central Mortgage and Housing Corporation, and therefore subject to the C.M.H.C. Building Standards*. The

Table IV

Typical Transportation Costs

Two trips per day of 10 miles each: 5 days per week: 50 weeks per year	ANNUAL COST
(a) If public transportation is used, at 25c per trip	$125
(b) If private car is used with single passenger at 10c per mile	$500
(c) If private car is used, shared by 4 passengers at 10c per mile	$125

* Published by the National Research Council, Division of Building Research, as "Housing Standards" since Jan 1st 1958.

Corporation permits the statement to be made that few, if any, of the houses built under the NHA have been constructed down to the minimum requirements of their "Building Standards".

There are other standards, however, in the housing field, those purely personal preferences which arise from social pressures. Lest it be thought that this is a facetious reference, Table V is included to show how these "social standards" (and certain other factors) do affect the cost of housing. The figures represent national averages for single family houses constructed under the National Housing Act for the years noted.

(*i*) It was not "Standards" or "Codes" that caused the increase here noted but mainly the desire of the average purchaser to get a larger home than the minimum required under CMHC requirements.

(*ii*) Although the increase in the size of the average home is surprising, some increase in the cost per square foot for house building is to be expected in view of the decrease in the value of money between 1947 and 1957. When it is recalled that during the period under review the actual value of the building dollar has decreased by about 43%, it will be seen that Canadian builders, on the average, have been doing a good job and that they are not to be blamed for the state of housing costs in this country today.

(*iii*) This increase is typical of the figures commonly used in current popular discussions of housing costs. It will illustrate the misleading character of cost comparisons on a total cost basis (a matter to be dealt with in the next section). Its true character can only be realized when it is recalled that it includes for a much larger average size of house as well as the over-all increase due to the change in the value of money in these last ten years.

(*iv*) Finally, if there are any doubts about the serious effect that land costs have had upon housing costs, this over-all national average of an increase in the cost of land for single family dwellings of 336% should serve to remove all such indecision. When it is remembered that in many smaller localities, the cost of building lots has not changed appreciably, the full significance of this figure will become apparent. It must be pointed out that a part of the increase shown must almost certainly be accounted for by the fact that it is more common today than in 1947 to include in the cost of land for housing the cost of the necessary services. Making every possible allowance for this, however, and for the change in the value of the dollar since 1947, the fact remains that increases in the cost of Canadian building lots in the last decade cannot be rationalized in any way at all; the increase constitutes one of the major unsolved problems in the high cost of housing in Canada today.

How Should Capital Costs Be Compared?

The third column in Table V shows clearly how misleading a comparison of unqualified capital costs for housing can be. It is therefore essential, in any reasonable discussion of housing costs, to specify capital costs with reference to (*a*) the year of building and (*b*) the size of house involved.

All citizens are well aware that the value of the dollar has changed appreciably during recent years. A convenient way of measuring the change, with reference to housing costs, is by means of a "construction index", a figure compounded from a number of individual unit costs which, together, give a good general index for true building costs in any one year. Typical constructions cost indices are:

1929	–	100
1940	–	93
1955	–	235

These figures show that building costs in 1955 (and so today) are at least two and one half times what they were in 1940, due only to the change in the value of money. It is therefore essential that when capital house costs are mentioned, the year of construction be given too, so that due allowance can be made for the change in the value of money.

It is not without interest to note that, in view of this, and making allowance for the change in the standards of house equipment (such as the modern heating systems and tiled bathrooms, demanded today) it can easily be shown that the true value of house structures as built in Canada today is at least as good as, if not a good deal better than, the value of houses built before the war.

Total costs of houses must also be defined in relation to the size of the house in question, as can be seen from Table V. A common way of doing this is to divide the total cost of a house by the finished floor area, thus getting a cost per square foot of floor, as used in the table. This is a useful "unit cost", much more meaningful than any total cost can ever be. At the same time, even this unit cost can be somewhat misleading. Its use is based on the assumption that the ceiling heights are the same for all the houses, the costs of which are to be compared. This may be true if all the houses under review have been built under C.M.H.C. regulations. But if older houses, or some houses of advanced architectural design, are to be included in any comparison, then square foot costs may not be accurate since the volumes of enclosed space represented by one square foot of floor area will not be the same. Further than this, the calculation of the "finished floor area" of a house (especially if stairways are involved) is not a straightforward matter and, to some extent, is dependent upon individual judgment.

An alternative suggestion has been advanced of measuring the total area of finished floors, walls and ceilings, i.e. the total finished area within the house, and then dividing the total cost by this figure to give a unit cost per square foot of finished surface.

Table V

Estimated Costs of Single-Family Dwellings Financed Under the National Housing Acts

Source: Canadian Housing Statistics, C.M.H.C., First Quarter, 1958, Table 60, page 39.

Year	Average Finished Floor Area sq. ft.	Average Construction Cost/sq. ft.	Average Estimated Costs* Construction***	Land**
1947	839	$ 6.91	$ 5,796	$ 523
1957	1,154	$10.48	$12,100	$2,293
Increase	38%	52%	109%	336%
	(i)	(ii)	(iii)	(iv)

* Estimated by loan applicants.
** Land cost data reflect the prices paid for lots. These prices vary with changing proportions of fully serviced, partially serviced, and unserviced lots. In the case of serviced lots, prices also vary with changes in the method of financing as between municipal financing, where part of the cost is covered by local improvement charges, and full financing by builders or developers.
*** 1957 figure includes the cost of oil burners; 1947 figure does not.

Theoretically desirable though such a unit cost might be shown to be, it is very cumbersome and time-consuming to use in practice. There is, fortunately, another type of unit cost that is very much easier to use, that is clear cut in application, and that can conveniently be applied to any type of building. This is to determine the cost per cubic foot of usable space within the outer shell of a house. The total volume is easily calculated, and even though slight errors (or differences) might be made in the over-all dimensions selected for the volume calculation for any particular building, the error thus produced in the final total volume will usually be so small as to be negligible. It is therefore recommended that, in all comparisons of house costs, the *year of building* be always mentioned and that *costs per cubic foot* should always be used as the basis of comparison.

Some Examples Of Cubic-Foot Costs

Costs per cubic foot have been used as indices of building costs by architects and engineers for a long time. There is, therefore, much relevant and useful information available from which the limiting values for "cube-costs" as they are sometimes called can be determined. Based on 1958 prices, the following ranges of cubic foot building costs will be found to be applicable in Canada:

Extreme Limits	50c to $3.00
Limits for Normal Buildings	60c to $2.00
Limits for Residential Buildings	75c to $1.50

These limits will be surprising to some readers, especially when it is realized that the range of unit costs for residential buildings is only in the ratio of 1:2. Since this includes domestic accommodation from the simplest type of shelter to the most completely equipped and beautifully finished house, it will be seen that the possibilities for major savings in the cost of the structure of houses of a given size is strictly limited.

Table VI is presented to illustrate the utility of the cost per cubic foot as a basis for comparison of house costs. The figures quoted show clearly the slight variation there is, for the unit cost of buildings in Toronto in 1955, despite differences in type, in floor area, and in total cost. Table VII illustrates the application of the same unit-cost procedure to large blocks of flats and apartments, showing clearly that typical unit costs of this type of housing today have a spread in cost only of between $1.05 and $1.43 per cubic foot.

Table VI

Typical House Costs For Toronto 1955

Source: Royal Commission on Canada's Economic Prospects. The Canadian Construction Industry, Study No. 34, The Royal Bank of Canada. Ottawa, Oct. 1956, p.200. (Based on C.M.H.C. figures; a uniform ceiling height of 8 feet is assumed)

Type of House	Area sq. ft.	Cost $	Cost per cu. ft.
6-Room Frame	1,650	15,150	$ 1.15
6-Room Brick veneer	1,165	11,800	1.25
6-Room Brick	1,520	14,800	1.22
Frame Ranch	1,170	11,750	1.25
Brick Veneer Ranch	840	9,200	1.37
California Bungalow	992	10,250	1.28

Table VII

Unit Construction Costs For Large Apartment Blocks

Sources: Royal Commission on Canada's Economic Prospects. The Canadian Construction Industry, Study No. 34, The Royal Bank of Canada. Ottawa, Oct. 1956, p.200. (Based on C.M.H.C. figures; a uniform ceiling height of 8 feet is assumed) and Engineering News-Record, Vol. 160, p.91, March 20, 1958

City	Type of Structure	No. of Apartments	Cost $	Cost per cu. ft.
Toronto (1955)	Brick	18	112,550	1.06
Toronto (1955)	Brick	30	178,350	1.05
New York (1957)	Brick and Reinforced Concrete	148	1,985,700	1.43
New York (1957)	Brick and Reinforced Concrete	2,025	21,556,064	1.12

How Can Reductions In Cost Be Achieved?

Behind all the foregoing analysis of housing costs is the continuing question which is of such concern in Canada today — how can reductions in house costs be achieved, with special reference to the needs of those citizens whose incomes are lower than the national average. If it has done nothing else, this analysis will have shown that there is no easy answer to this question.

It will now be clear that there is no single factor which can be blamed for the "high cost of housing" since many factors combine to make the cost of residential accommodation what it is today. Let it be said once again that the cost of a house structure itself is not, as is so commonly supposed, the only item of importance in such considerations.

It has been shown that from the long-term point of view the only sound basis upon which housing costs can properly be judged is by considering the real or annual cost. Sound though this point of view most certainly is, it is admittedly difficult to get the "man in the street" to appreciate this essential aspect of housing costs when he is faced with the problem of finding the down payment and arranging for the necessary monthly payments of the house he wants to buy.

Even though a reduction in first or capital cost is what the average citizen would like to see in connection with the housing that he needs, reference to Table III will show clearly that quite the most important factor in the cost of housing in Canada today is the cost of money, as represented by the interest and the necessary capital investment and in the calculation of the necessary amortization payments. It can be stated without qualification that an appreciable reduction in the interest rate upon money would do more to reduce the cost of housing in Canada than any technological improvements in house structures that can be foreseen at present. This does not imply that no technical improvements are to be expected, the statement rather placing emphasis where it should be placed in any over-all assessment of housing costs today.

When Table II is considered in relation to Table IV it will be appreciated that the most serious increases of cost have occurred in connection with the land necessary for house construction in urban areas. What can be done to control or reduce present land costs is a matter beyond the province of this paper. It must be stressed, however, that much of the basis for the complaints made today against the "high cost of housing" is to be charged against the high cost of developed land and not to the cost of house structures themselves.

Turning next to the cost of house structures, but remembering that this item is only one of many in the whole picture of housing costs, it has been shown that part of the recent increases in the average cost of housing in Canada is attributable to the steady increase in the size of the average Canadian single family homes built in recent years. One most effective way of reducing housing costs is, therefore, by reducing the size of houses built for sale, at least down to the minimum level required by current housing regulations. Such a move would have to be made, however, in the face of public demands for changes in exactly the opposite direction. Only when houses are being built to approximately the minimum sizes called for under current regulations can complaint properly be made that codes or standards are standing in the way of further reductions in cost.

It may be objected that all the costs cited for house structures relate to what can best be called conventional construction as practiced in Canada today. This is true, but a detailed analysis of the costs of the various components of houses — such as the foundation, the walls, the floors, the roofs, and the necessary equipment — shows quite clearly that even the use of some radical new material for one or more of these components, if it were to be generally accepted by Canadian householders, would have a relatively small effect on the total capital outlay for a new house and correspondingly upon the real or annual cost of such accommodation.

Small though such cost reductions may be, they will contribute their small quota to the over-all and desirable reduction in housing costs. Search for such technical improvements is the continuing responsibility of the Division of Building Research of the National Research Council which works, in this field, closely with Central Mortgage and Housing Corporation and with such bodies as the Forest Products Laboratories of Canada. Theoretical analysis and laboratory studies are in progress, and have been so for some time, into possible improvements not only in house structures (for which purpose a full-scale house was tested almost to destruction) but also in relation to the main components of housing structures. A recent publication put out jointly by DBR, CMHC and FPL, which presents a series of designs for wooden roof trusses, is but one indication of the advances that are being made, steadily if slowly, in this direction.

Many Canadians point to experiences in other countries in low cost housing developments and ask why the same results cannot be achieved in this country. In their continuing search for improvements in housing, the writer and his colleagues in the Division of Building Research, N.R.C., have now visited more than a dozen other countries in order to study local house building methods and housing practice. Nothing has yet been seen which would suggest that Canadian house builders are neglecting any technical advances which would contribute appreciably to the reduction in the costs of single family dwellings. When low cost housing is achieved in other countries, and this applies particularly to Scandinavia, it is found in every case to be due to a combination of the use of multiple dwelling apartment blocks, with living areas much smaller than are used in Canada today, and low interest rates ranging down even to 1¾%, associated with amortization periods up to 75 years.

Conclusion

It is not the province of this paper to comment upon the possibilities which any of the foreign practices present for the Canadian scene since so many sociological factors and matters of public policy are involved. The conclusion is inescapable, however, that, looking only at the Canadian scene and without reference to the experience of other countries, one development to be expected may well be a change in the trend of Canadian housing towards the redevelopment of central urban areas rather than a continuation of the building of single family dwellings on the steadily expanding peripheries of Canadian cities. In this way land costs can be controlled, land can be put to more efficient use than at present, unnecessary transportation costs can be avoided, and some progress made towards actual reduction of the cost of housing structures themselves by competent design and construction which utilizes the facilities of large construction equipment rather than the efforts of the builder of single homes.

Attention is directed again to Table III since it points so clearly to other conclusions, notably the importance of the "cost of money" in any consideration of the true cost of housing. For example, if it were possible to borrow money in Canada today for first mortgages on houses at an interest rate of 5%, the change from 6% to 5% in the Table would mean an annual saving of more than $240, or more than 10%, a saving that can not be achieved at present to the same extent in any other way, without reducing appreciably the size of the house.

It is well accepted practice in Canada to regard approximately one quarter of a family's income as the maximum amount which should be spent on the provision of shelter. Applying this to Table III (and using 24% for convenience) it can be seen that a house costing, with land, $20,000 corresponds to an annual income of

$$\frac{2400}{24} \times 100 = \$10,000$$

This suggests as a guide to thinking in Canada today about house costs (i.e. at 6% interest), that the *total* capital cost of a single family house should not exceed twice the annual family income. For those with annual incomes of $5,000, the "$10,000 house" is therefore the maximum that should be considered. This is the real challenge of low-cost housing.

The main conclusion to be drawn from this study of housing costs in Canada today is that there are no miracles to be expected in the direction of sudden and appreciable reductions in the cost of housing of any type. So many factors are involved and they are so closely interwoven that cost reductions, when they can be achieved, will only come gradually and cannot possibly be of any considerable magnitude without rather drastic changes to the social and economic setting in which housing in Canada today must be viewed. It may be objected that nobody bothers to think about the over-all economics of housing in Canada today, as outlined in this paper. To this there is only one reply which can be made — they should.

INSTRUMENTATION IN INDUSTRY

INTRODUCTION

to a series of articles
to be published in

THE ENGINEERING JOURNAL

Systems engineering is not a new discovery. It is a common engineering approach, with a new and important meaning because of the greater complexity and scope of problems to be solved. While it can be extremely complex it may be simply defined as "logical engineering within physical, economic and technical limits", bridging the gap between fundamental laws and a practical operating system.

Instrument and control engineering is simply one aspect of systems engineering. It is vitally important and highly publicized, because ability to create automatic controls within overall systems has made possible the reaching of objectives never before attainable. Though automatic controls are vital to systems that are to be controlled, *every* aspect of a system is essential.

Control engineers have been leaders in building up a systems approach in the various technologies. Some of them have gradually become specialists in measurement and control, and this has created the nucleus of a new emphasis on systems engineering.

Systems engineering calls for highly trained technical personnel. Its direction must be closely tied to top management and must be recognized as more than merely a mechanical job, since it involves both technical training and administration. With the current shortages of university graduates, engineers now employed in industry should be given every opportunity to become trained through practical experience in this field.

Extending as it does over all types of industries and technologies, instrumentation is rapidly approaching the status of an independent profession. If this recognition can be achieved it will benefit everyone connected with this relatively new branch of engineering.

Purpose of the Articles

In this issue *The Engineering Journal* publishes the first in a series of articles relating to instrumentation in Canadian industry. This series has been designed and is being undertaken by the Engineering Institute of Canada as a service to Canada's fast growing and widely diversified manufacturing and processing industries. Through it, it is hoped, companies within each group covered will benefit from the information reported by other organizations in the same group. But the long-range purpose of the series is the exchange of 'knowhow' about instrumentation between one group and another, to show how any industry may adapt methods used elsewhere to its own advantage.

The articles covering various industrial groups and the monthly issues in which they will appear are scheduled for 1959 as follows:

- January: Chemical Manufacturing
- February: Pulp and Paper
- March: Food Industry
- April: Metal Fabrication
- May: Power—Development and Distribution
- June: Waterworks
- July: Steel Making & Foundries
- August: Oil and Gas Industries
- September: Chemical Processing
- October: Modern Boiler Rooms
- November: Textile Industry
- December: Business and Institutional Buildings.

In general, the object of the series is to determine to what extent the application of instrumentation and control lead to more uniform production; how costs per unit can be reduced; how installation of instruments has already cut down operating costs; how it has reduced spoilage and led to greater uniformity in the end-products, and speeded up production.

Other information to be brought out will deal with: initial cost of instruments, the cost of maintaining and repairing them, and the resulting over-all savings; how long it takes to recover the original investment; who is responsible in the plant for maintenance and repair, and what these items cost annually; who specifies the types of instruments; who buys them; who installs and services them; and what are the various instrument applications.

Firms representative of each industry grouping are being approached for specific information. They are being invited to indicate the source of information, but the companies' names will not be published. Manufacturers or suppliers of instruments are not being asked to supply data required for this series.

INSTRUMENTATION IN INDUSTRY

Part One of a Series

CHEMICAL MANUFACTURING

IN 1957, THE LATEST year for which full statistics are available, there were 1,140 plants in Canada with some 54,600 employees in the entire chemical and allied products group, of whose products the selling value amounted to $1,201.6 million. Materials used that year in manufacturing processes cost $561.9 million, and fuel and electricity cost 42 million. Salaries and wages amounted to $218 million.

Imports were valued at $293.8 million, and exports at $195.3 million. Only fertilizers, toilet preparations, and miscellaneous groups showed declines from the previous year. Greatest gains were shown for vegetable oils, 42.7%; heavy chemicals, 17%; compressed gases, 15%; medicinals and pharmaceuticals, 12.2%; primary plastics, 12.2%; adhesives, 10.6%; soaps, polishes, and dressings, each 9.1%; paints, 5.5%. Profits, however, did not increase in proportion, due to higher labour and capital costs.

In 1958, sales of all chemical products during the first nine months showed an increase of some 7.3 per cent over the same period of 1957.

Though statistics do not record a breakdown as between chemical manufacturing and chemical processing, due to considerable overlapping and to the fact that many firms both produce and process chemicals, manufacturing probably accounts for about 40 per cent of the total selling value.

Fivefold Increase Foreseen by 1980

For the immediate future it is anticipated some sectors of the industry, for example those producing chlorine and alkalies, will be operating below full capacity due to the current slowdown in consuming industries. In contrast, however, the production of sulphuric acid has risen sharply and will continue to do so in 1959, due to greater production of sulphur as a by-product from natural gas, and to a sharp rise in consumption for leaching uranium ores.

Despite the possibility of a period of overcapacity during the next year or so, the longer term prospects for the industry are full of promise. The Gordon Commission predicted the volume of chemicals produced in Canada would represent some 10 per cent of the GNP by 1980 as compared with 5½ per cent in 1928, or about five times the volume produced in 1955. This would amount to a selling value of more than $5 million in constant dollars.

What Producers Say About Instrumentation

As might be expected in a country where almost every manufacturing area enjoys an abundant supply of dependable and cheap electrical energy, nearly all chemical industries buy their power from central electric stations. A few, however, have standby equipment and alternative fuel supplies available to maintain heating, process steam, light, feed-water and compressed air supplies in the event of a temporary shut-down.

Generally, input and output of power is not checked by the manufacturer, who relies entirely on the metering recorded by the utility from whom he purchases electrical power.

• The information contained in this article is based on replies to a questionnaire sent to chemical companies with manufacturing centres located across Canada.

• As expected, the replies to specific questions have shown a wide diversity in the extent and use of instrumentation. Therefore this article, in common with succeeding items in the series INSTRUMENTATION IN INDUSTRY, has been written to present a cross-section of the extent of utilization and the cost of instrumentation within a specific field.

• Those who replied to the questionnaire from which this article was compiled are producers of heavy or industrial chemicals, acids, alkalies, ammonia, primaries for plastics, organic chemicals, and compressed gases; and allied organizations that use chemical engineering principles.

Steam Power Plant Instruments

Instruments most commonly used in the steam boiler plants are those for boiler control and for metering steam-flow; for recording and controlling air-flow, steam pressure, temperature, boiler output, and feedwater. A list of such instruments would normally include flow-meters; oil pressure gauges; draught gauges; level controls; temperature and steam pressure controllers and gauges; control valves; and thermometers. The capital cost for the entire group of these devices is normally estimated at between $5,000 and $10,000, depending on the size of the plant.

In most cases separate plants are not used for steam heating and processing, the one steam boiler plant being used for both purposes. Most of the replies received indicated that the instruments in these boiler plants were installed at the time the plant was originally built, with only minor changes and additions made as requirements demanded. Provision has been made for the installation of further instruments whenever the investment is justified for costing or for proper control of the operation. Steam is rarely used for power generation, but almost entirely for heating buildings and for processing the chemicals produced.

Who Specifies the Instruments?

Instrumentation installations in the original plant are usually designed and specified by consultants in conjunction with the company's engineering department. Any additional instruments found to be necessary during operation are generally designed and specified by the manufacturer's own staff.

Some companies have had instruments supplied with their boiler plant, but in other cases these have been installed during the construction period. Frequently an instrument engineer is maintained by the company, who recommends, and designs or specifies, additional instrumentation when the need arises.

Instrumentation in Manufacturing Plants

It is in the manufacturing plant that the application of automatic instrumentation differs between one type of product and another, and between various companies producing the same or similar end-products. This is mainly due to differences in the chemical processes used.

Most chemical manufacturing uses continuous processes, controlled by automatic instrumentation. This is largely pneumatic, though in some cases electronic devices are used; for example, for pH analyzers, chemical composition, oxygen analysis, and so on. Controllers, indicators, and recorders are installed for controlling measuring, and recording process steam, fluid flow, pressures, and temperatures. The trend appears to be towards broader use of spectroscopic instruments for in-line analytical work.

In this field, as in the case of boiler plants, initial instrumentation arrangements have been designed, specified, and installed under the direction of the consultants, though in the case of some smaller manufacturers this is done by the company's own engineering department. It appears to be the general practice to purchase all instruments outright. Though in most cases specifications are drawn up by the company engineering staffs, advice is sought from consultants for the more important and expensive pieces of equipment. Instruments are generally bought through the company's own central purchasing department, on the recommendation of the engineering department.

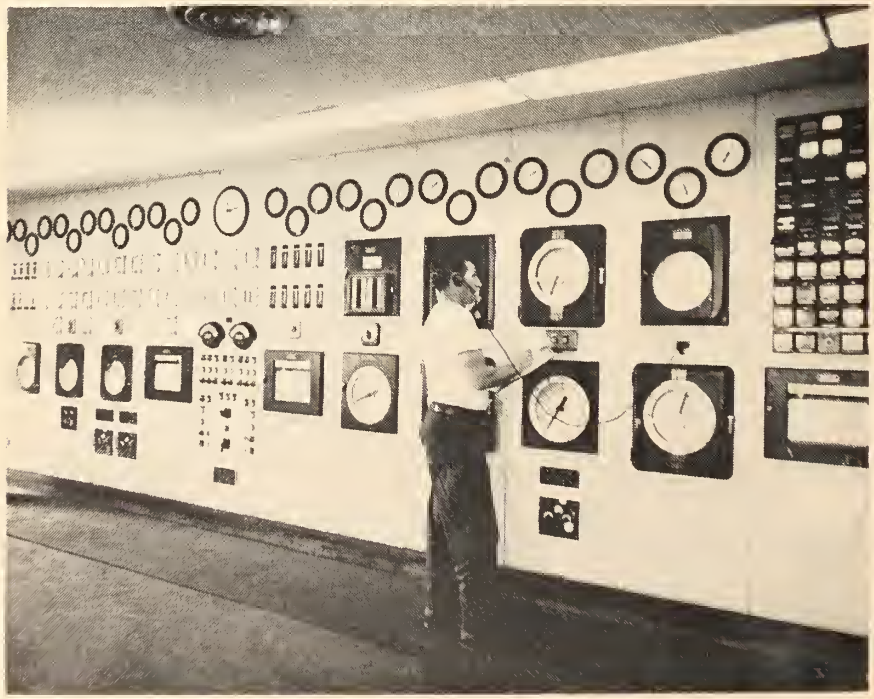
Replacements and Repairs

Though some of the smaller producing companies carry a complete line of replacements, the trend is for the larger industries to carry inventories of only the most essential parts for replacement and repair, as indicated by experience.

The practice followed depends on the importance of the instrument involved and on the availability of parts from the supplier. Occasionally subassemblies are carried in stock for quick interchange, and in special cases a few complete spare instruments are kept on hand to avoid delays in shipment, clearing of customs, etc.

Most of the larger chemical producers do their own servicing and repair work. Often it is found that in smaller plants this can be accomplished with one first class mechanic, skilled in the use of very fine and up-to-date tools. Larger establishments may require several top-notch mechanics working full time. Reliance on instrument manufacturers for repairs and upkeep is usually limited to the most complicated work, such as a complete thermal system or temperature instruments.

Brain centre of the ammonia plant of Canadian Industries Ltd. at Millhaven, Ontario, is the control panel where almost every facet of production process is indicated. Many of these can be controlled by the board man. Operator wears phones to keep in touch with other operators in the plant through an intercommunication system.



Costs and Maintenance of Instruments

Capital cost of instruments including cost of installation varies widely between large and small producers. A large company with several plants and diverse products may have an investment for instrumentation running as high as $1 million, and the average for smaller companies appears to be in the vicinity of $25,000 or even less.

Annual maintenance reported varies accordingly, with figures of between $25,000 and $30,000 yearly for a large comapny, and some $4,000 yearly for the smaller producer. Annual cost of servicing and repairs only, exclusive of replacement parts, would approach $15,000/20,000 yearly, in the case of the larger company, wheras for the smaller plant it might be as low as $1,000.

One large producer of heavy chemicals which does its own replacing, servicing, repairing, recalibration, etc., estimates that it uses one man per each $3-million worth of plant investment. Its annual cost for building, test equipment, and repair equipment amounts to about $6,000 for each of its own instrument maintenance employees.

Savings Through Instrumentation

A most important aspect of the information sought was "How much time and money is saved by the use of instrumentation in various departments, namely, . . . in fuel consumption, regularity in pressures, evenness of flow, quality of product, saving in man-power, etc." Answers here varied widely depending on size of plant, number of different departments or products, number of shifts operating per day, and length of time the company had been in operation.

The reply from one of the major

producers of heavy chemicals emphasizes the difficulty in answering, and points up the resulting reluctance on the part of some producers to give a definite answer. In this instance, the producer's comment was: "The degree of automation is set by the complexity of the process and the close tolerance of product specifications. It is doubtful that operation without instruments would be feasible or safe. Minimum man-power for safe operation, and for requirements should emergencies arise, limit further economic use of instruments."

The reply to the same question from another producer read: "This plant would not be operable without automatic control. Some 150 control loops give continuous surveillance to the process. Without them, perhaps 50 or 75 people could do this same job with perhaps the same quality of product." (The reply noted that the alternative use of manual control is of academic significance only.)

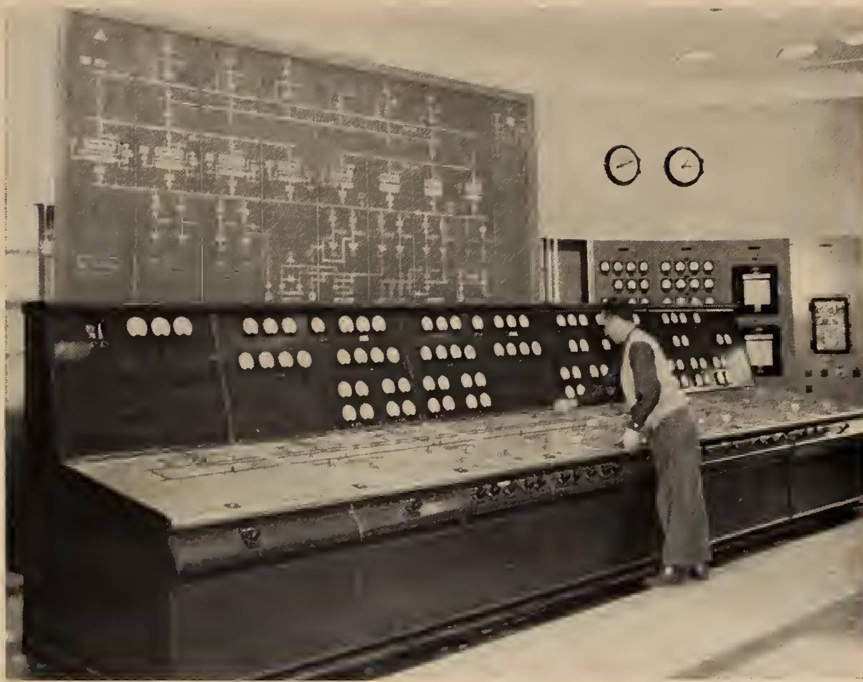
Larger chemical producers found even more difficulty in giving specific answers. This has been particularly true of the larger plants which have had complete instrumentation systems from the start of operation, as is generally the case. Such plants would, of course, not be able to function today without automatic control.

Smaller plants, with only limited use of instruments, generally had less difficulty in assessing the savings in such terms 'one man per shift'. In these cases an annual wage saving of some $4,500/14,000 per year could be visualized, depending on the number of shifts operated. This, however, is of little informative value unless related to the average volume of output of product.

Instrumentation Here to Stay

Many of the important chemical producers in Canada have been established more recently than their American or European counterparts, and were able to prepare for production after the general introduction of automation. All replies indicated a growing tendency towards extensive instrumentation, and in cases where extreme accuracy is essential the general opinion was "The plant could not operate without it."

In other cases, where controls and instruments are not immediately essential, they are being added piecemeal to existing plants, and more are being incorporated in designs for new plants than would have been the case even a few years ago. It is known that this greater application of instrumentation will result in higher efficiencies, more constant or improved quality of product, and greater ease of operation.



Section of control room at Shawinigan Water and Power Company's Trois-Rivières Terminal station. The alarm and light diagram is in the background. At far right on the wall is the automatic synchronizer and under the clock is metering for capacitors. On the benchboard are switchgear controls and meters for main transformers.

Trend to More Instrumentation

The important point brought out by this initial study is the conclusion that future trends in chemical production are toward the increasing use of instrumentation, as new instruments are brought on the market and whenever such installations can be justified economically. There is a strong tendency to the use of process steam analyzers and sequence controls, as well as to greater use of electronic instruments, and this trend is expected to continue.

Canadian producers are fortunate in having access to information about new developments in instrumentation in Canada and other countries. Canadian instrument engineers are ever alert in watching for improved processes and the introduction of new and better instruments. Many Canadian chemical producers are associated with foreign companies and can benefit from the latter's research and experience.

There is little doubt that the returns from the other eleven industries listed in the "Foreword" will disclose important information about their basic experience with instrumentation and the savings effected thereby. Perhaps some of this experience can be adapted by the chemical industry to its advantage.

EDITOR'S NOTE

It is appreciated that the vast scope of the field to be covered by this series of articles will make it impossible to go into detail with respect to the varied applications of instruments.

Therefore, it is planned to write the articles so that they will be of interest to engineers engaged in all phases of the profession and industry.

Readers' comments and suggestions on this, and other, portions of THE ENGINEERING JOURNAL will be gratefully received.

INTERNATIONAL NEWS

MAIN ACHIEVEMENT OF ELECTRONICS IN JAPAN

REMARKABLE PROGRESS in electronic techniques has recently been made throughout the world and Japan has also been studying them in various fields with excellent achievement, some examples of which will be introduced here.

Super-multiplication of Micro Waves and TV Relay Device

The multiplication communication by micro wave has been studied since 1948 using disc seal tubes or magnetron tubes, and in 1951 a 23 channel device of PPM-AM system at 4,000 m c/s was completed into practical use. This device was installed between Tokyo and Yokohama by Japan Telegram and Telephone Corporation and between Aomori and Hakodate by Japan Railway Corporation.

Researches on the super-multiplication device have been conducted for the public communicational use by means of a disc seal tube and a travelling-wave tube. However, from a manufacturing point of view, the travelling-wave tube was deemed to be more prospective, and FS-B1 apparatus of 480 tone channels was developed. This apparatus was applied to the construction of the super-multiplication telephone lines and TV relay lines between Tokyo and Osaka in March 1954. This is an FM modulation system at frequency range of 3,700-4,200 M c/s, by means of path length antenna and 2-stage travelling-wave-tube amplifier (transmitting output of 1W). After that, FS-B2 apparatus, an improved system, was applied to the construction of the telephone and TV lines between Tokyo, Sendai and Saporo in September 1956. The micro-circuit-lines have been set at almost all the main cities in Japan. The whole relayed distance of these public communications at 4,000 M c/s band attains 10,338 route Km (1 route has a capacity of 480 telephone tone channels or 1 TV line) and the expansion plan is being successfully carried out. The principal characteristics of FS-B2 system are: the frequency range of 3,700-4,200 M c/s, FM modulation system, 11 feet parabola antenna, 1 stage travelling-tube amplification (transmitting output of 1 W), no-break-alternative power supply system and no-man-station system.

Additionally, the 120 telephone tone channels or the TV relay apparatus at 2,000 M c/s band by a disc seal tube is put into practical use for the local lines. The micro wave ST link apparatus which combines the TV broadcast stations and the TV relay line terminal stations is used at 6,000 M c/s band. Besides, Japan National Railway Corporation and other electrical power companies established their own specific telephone lines.

Electron Microscope

The research on the electron microscope began in May 1939 when the Electron Microscope Subcommittee of Japan Society for the Promotion of Science was established. At that time the study was mainly proceeded in Germany where the invention was made, and was still in its early stage. Nevertheless, many specialists both in scientific circles and industrial fields, participating in the committee, cooperated with each other and pushed forward vigorous research activities. As a result, an electron microscope of highest ability in the world was developed, and this achievement was highly evaluated at the International Electron Microscope Society held in Tokyo in October 1956. Japan has already exported the electron microscopes to many countries such as U.S.A., France, U.S.S.R. and others.

Some examples of the electron microscopes manufactured in Japan are as follows: Hitachi Manufacturing Co. have developed the research on the block lenses made by an ultra-precision finish, using them at the high excitation of magnetic fields. A great achievement was reached in eliminating aberration and an HU-10 type electron microscope of high efficiency with dissolving power limit of 10 AU (angstrom unit) was manufactured. Further, a middle size microscope of HS-6 type (dissolving power 25 AU) and a popular table model of HM-5 type (dissolving power of 80 AU), are being produced. Those two types, utilizing a permanent magnet, can be maintained and adjusted easily.

The Japan Electron Optics Laboratory Co. carried on trial work which has led to the manufacture of the universal JEM 5 type electron microscope. As for its major characteristics, it is noted that its dissolving power attains 10 AU, and a diffraction pattern as well as a transmitting image can be observed in the same region, thus a new application field has been developed in obtaining a reflective image (at any angle of reflection within 30° by deflecting continuously the incident electron beam). In addition, a minor test piece heating furnace enabling the observation of configurations up to 1000°C and a cooling apparatus at low temperature of 180°C below zero are attached to the electron microscope so as to make it possible to observe the configurations of metals at high temperature and the conditions of water, mercury and fibre when cooled.

The strong requirements of scientists especially in the medical field and the effort made by scholars and private companies for the competition of manufacturing microscopes have brought the development of the microscope in Japan. The number of the microscopes in Japan now amounts to more than 400, being next to that of USA and nearly equal to that of USSR, and has made a great contribution to scientific and technical researches.

Parametron

Successful development has been achieved in Japan in the research for the application of electronic techniques as artificial brains to electronic computers, telephone exchangers, automatic controlling devices in the manufacturing process, and so forth. Several instruments in which relays, transistors and vacuum tubes are used.

have already been put into practical use after completion of the development stage. The parametron was invented in Japan in 1954 and proved to be a computing element as superb as these elements.

The parametron, as its name indicates, is a non-linear reactor utilizing the parameter exitation, and is used for amplification, memorization of information and standardization of phase and amplitude. It is similar to the memory elements which use the solid magnetic amplifier or rectangular hysteresis magnetic core and is recently being developed in America. However, it completely differs from them in its principle, and great hopes are placed in its future application, since it has been developed with the electronic techniques peculiar to Japan.

The parametron is simply manufactured by winding a coil around the new ferrite which is made by sintering the oxide iron after adding copper-zinc or nickel-zinc compound to it. The manufacturing cost is extremely low, and the product is of very small size (about 4 mm in diameter and 1 mm in thickness), but is durable almost indefinitely.

As it has advantages in that its action is stable and it requires no maintenance, it can be applied to electronic computers and electronic exchangers in which thousands of parametrons are used. It is true that parametron which is in practical use has slight disadvantages in that it consumes electric power of approximately 20 mV and its logical computing speed is 40 mmS, but research work is expected to increase its speed and reduce its power consumption to some extent. Moreover, compared with other electronic theoretical elements, it is highly advantageous and prospective in future that a single parametron possesses the maximum logical dividing number of 30 by which it can provide logical variables to as many as 30 independent logical systems.

Musasino-1 is the first enormous electric computer using parametrons and was completed at the Communication Laboratory of Japan Telegram and Telephone Corporation in February 1958. It uses about 5,000 parametrons and possesses memorizing capacity of 256 words by means of the core matrix system, and is expected to possess memorizing capacity of 1,024 words by March 1959. The computing speed is 1 mS (at 30 KC) or 2.5 mS (at 10 KC) in addition and 3.3 mS (at 30 KC) or 10 mS (at 10 KC) in multiplication. In other ways a computer, a PC-1 type of the same efficiency has been developed at Tokyo University since this spring and a revised PC-2 type is expected to be completed by March 1959. The trial manufacture of this type has already been developed by a private company for commercial purposes.

BELGIUM

THE ENTRE National de Recherches Métallurgiques (Belgium) has entrusted the Brassert Oxygen Technik A. G., in Zurich, the holders of which are the Austrian steelworks Vereinigte Oesterreichische Bisen-und Stahlwerke A. G., in Linz, and Oesterreichisch-Alpine Montangesellschaft A. G., in Donauwitz, with the commercial exploitation in countries other than Belgium and Luxemburg, of the new steelmaking process which has been developed in the steelworks of Arbed (Luxemburg) in collaboration with the Centre National de Recherches Métallurgiques. This process which is known under the name of the O.C.P. process, has been described in a communication presented at the International Iron and Steel Meeting held in Liege in June 1958.

To indicate the collaboration between the Austrian, Belgian and Luxemburg steelworks, the O.C.P.-process will be designated the LD-AC-process and the steel produced by this process will be marketed under the name of LD-steel. It will be possible to produce LD-steel from iron with any phosphorus content.

(*Continued from page 51*)

underground, and successfully operated.

5. Many factors influence the decision whether a particular waterpower is developed in the conventional manner or underground. Only a careful economic evaluation of the several possibilities can reveal the best solution.

6. Geological investigation of adequate scope and correct interpretation is essential to achievement of minimum construction costs.

7. The underground concept of development frequently permits much greater latitude in location.

8. The planned use of rock bolts can be a potent factor in economic construction underground in poor geological formations.

9. Underground power plants should be designed only in principle, pending entrance to the working area.

10. Experience based on numerous cases of underground development shows that well-planned projects can be economically built.

11. Operating experience has been good. Some failures have occurred due to inadequate allowance for controllable factors or improper design but they are very infrequent.

12. The Kemano, Bersimis I and Chute-des-Passes schemes, all in Canada, lead the world in capacity and in many other respects.

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Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

Lift Slab Construction at Carleton

In establishing a new campus on a 130-acre site in Ottawa, Carleton University is employing some of the latest building methods and materials. Of the four buildings now underway, perhaps the most revolutionary construction is that used on Norman Paterson Hall, the arts building. It is being constructed by the lift slab method.

In the four-storey, 45,300 square-foot building, all floor and roof slabs were poured at basement level, one on top of the other, using only edge formwork and a special A. C. Horn Separating Compound to prevent the wet concrete slabs from bonding.

Steel columns provided the vertical framing and the slabs were hoisted into position by Youtz-Slick hydraulic jacks. Only one half of each floor could be raised with each lift, which averaged 350 tons. The slabs were 96 by 56 feet in size and varied in thickness. The roof slab, first to be lifted, was eight inches thick. The main floor slab (second level of the building) was 11 inches; the other two, 10 inches each.

A three-foot-wide construction joint between the individual lifts was filled in using normal concrete shuttering after the slabs were in place.

Under favourable conditions, a considerable saving of time is possible with lift slab as compared to conventional methods since concrete can be poured directly into the slab forms without the necessity of hauling it above ground level. This saving applies also to reinforcing steel which can be put in place on the ground for all levels. Another possibility, not yet exploited to any extent, is the raising of large quantities of building materials and other supplies as the slabs are lifted.

The slabs had to be designed for the sum of two moment conditions, the first being dead load moment with no column restraint, which condition would exist during the lifting of the slab; the second, live load moment with full column restraint. Wind stiffness was provided by poured concrete shear walls eight inches thick. They were poured through slats and sleeves left in the slabs for this purpose.

Reinforcing steel was made up of straight bars ranging in size from ⅞ to ½ inch thick, to permit the free run of electrical conduits and pipes in the central part of the slab. Stair openings and duct openings were left in the middle strips.

The first row of 10 by 10 inch wide-flange columns was set back six feet from the edge of the slab. The columns were plated into a box section to provide stiffness against buckling for the lifting particularly of the first slab.

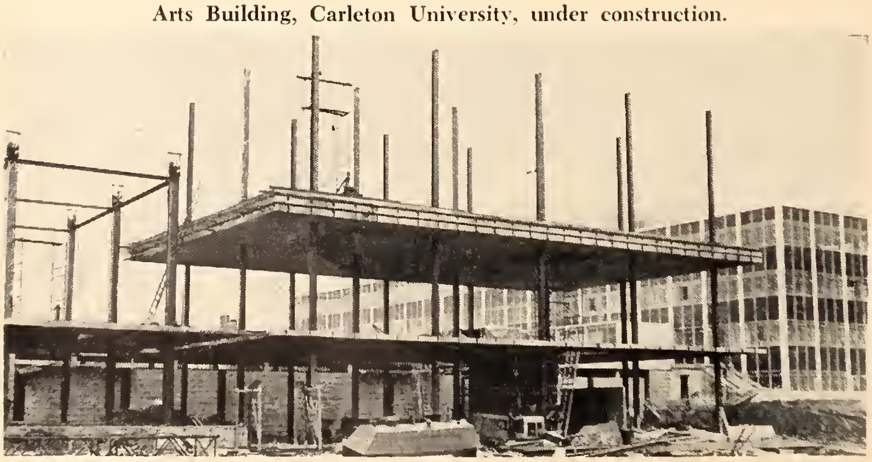
Inset steel collars cast into the slabs provided keyholes into which lifting rods could fit, as well as providing large bearing areas for the heavy slabs. The collars are supported by wedges which bear on shear plates welded to the face of the column. Small wedges were inserted into the top of the collar to provide column restraint and these and the support wedges below were finally welded to the column.

An interesting structural feature on the south side of the building is the main stairway which is supported on one side by Stressteel rods attached to cantilevered beams at the roof. The landings of the stairway are cantilevered in two directions from these supports.

Being constructed at a cost of $1,300,000, the arts building will be completed next summer. Other buildings are science, $2,500,000; library, $1,000,000; and a field house for athletics, $88,000. These three will be ready for occupancy early in the new year.

For 16 years since its founding, Carleton has been housed in a small red brick building in a residential area of Ottawa. Increasing enrolment and the need for more adequate facilities for the study of engineering, arts, science, commerce, journalism and public administration will force the university to relocate on its Rideau River campus as soon as possible.

Arts Building, Carleton University, under construction.



Correction

In the October, 1958 issue of the *Journal* page 67, *International Passamaquoddy Tidal Power Project*, by G. Millar, the statement was made that Dexter P. Cooper was a Canadian hydraulic engineer.

After extensive enquiries, it has been discovered that although Mr. Cooper spent much of his lifetime in Canada, and is buried in Canada, he was in fact born in the United States.

St. Lawrence Seaway and Power Project

Progress by Ontario Hydro

With employment averaging 1350 persons for November, placing of concrete was finally completed on the power-house. Eight units were operating, with installation progressing on other units. Most of the dredging upstream was expected to continue until mid-December.

Progress by NYSPA

Employment was maintained at some 1750 persons during the month. Placing of concrete reached 99 per cent of completion, and excavation had reached 94 per cent of the estimated total. On the American half of the power-house, eight units were operating, delivering 50 per cent of the total capacity in firm power. Tailrace excavation had reached a total of 630,000 yards.

At the Long Sault dam, painting of gates, hoists and equipment continued, and installation of elevators was resumed. Removal of construction plant and buildings and general cleanup work were in progress in all areas.

Cleanup of channel improvement at Toussaints and Iroquois dam was completed, while final sweeping of the ship channel in the Sparrowhawk area continued.

Progress by SLSDC

A force of 300 persons was employed during the month, most of it on cleanup and removal of equipment. The spare lock gate will not be delivered until March. Dredging in stretches of the channel where high velocities obtain, will continue as long as weather conditions permit.

Progress by SLSA

Employment during November averaged some 2500 persons on bridge erection, dredging, testing of lock gates and general cleanup. Water had been let in to the Cote Ste. Catherine lock and the two Beauharnois locks. The installation of lock operating machinery on these three locks was nearing completion but testing and final acceptance would be carried on throughout the winter. Dredging operations will be continued as long as weather permits.

On the CNR rail diversion at Victoria bridge, erection of steel was completed from St. Lambert to and including the crossing over the St. Lambert lock, except for the last three spans. All approaches at the south end of the Mercier bridge were completed and the completed north- and south-bound lanes on the Valleyfield-Malone approaches were opened for traffic during December. Erection of the towers for the lift-spans on the St. Louis and Valleyfield bridges across the Beauharnois canal was proceeding and would continue during the winter months. Traffic was passing normally over the Valleyfield bridge but was detoured at the St. Louis bridge.

New Bridge Opened at Massena

Inauguration ceremonies were held on December 1 to celebrate the official opening of the new $7 million, 5,000 foot long high level highway suspension bridge crossing the south channel of the St. Lawrence at Cornwall Island. The bridge crosses the International Boundary and gives an overhead clearance of 120 feet for ships. The main suspension span is 3,840 ft. long, carried on two 232 ft. towers each standing on two piers.

The new bridge replaces the old south channel bridge of the Roosevelt International Bridge some 1,300 ft. downstream, which has been removed. A new bridge is to be built by Canada across the north channel between Cornwall and Cornwall Island.

U.S. Subsidy Threatens Canadian Ship Owners

A new U.S. shipping subsidy bid has Canadian Great Lakes shipowners worried. American Export Lines, Inc. has applied for a subsidy for vessels to run between Great Lakes ports and the Mediterranean, and to designate the run as a new 'essential trade route'. One such route between Lake ports and Europe has already been approved. Indications are that the request will be granted. Canadian shipping firms see this as a threat to their livelihood once the Seaway opens, believing subsidies will spread ultimately to the U.S. Great Lakes fleet.

Progress on Winter Navigation in St. Lawrence

Good progress during the past year towards ending the 'needless blocking' of navigation in the Gulf of St. Lawrence, is reported by Arthur Schmon, president of the St. Lawrence and Gulf Development Association. Positive results towards easing the problem were being achieved through navigational aids, aerial ice surveys and additional ice-breakers, he said.

Two new $2.5 million icebreakers are under construction. Expenditures for harbour improvements costing some $2 million at Seven Islands, Dalhousie, Rimouski, and improvements in ferry service from Baie St. Catherine and Tadousac are being made. The federal government has earmarked $13 million for a winter port at Father Point. Two shipping companies, possibly three, will run scheduled services from Quebec City to north-shore points during the coming winter.

Tentative Plans for Opening of Seaway

Tentative plans at the end of November for the opening of the Seaway in 1959 by Queen Elizabeth and Prince Philip call for the Royal Visit at Montreal on June 25, 1959. Leaving the royal yacht at Sept Iles, the party will visit Knob Lake and Quebec City and will then re-embark at Quebec and proceed to Montreal. The official ceremony will take place in the Cornwal area, and will be a joint ceremony with President Eisenhower. The Britannia's main mast and its radio aerial have been hinged 20 ft. from the top so they can be lowered to permit passage under the bridges along the seaway.

Canadian Pipeline Projects

Trans Canada Pipelines

Trans-Canada Pipe Lines Limited, which completed construction of its 2,290-mile natural gas line in October, 1958, ahead of schedule and under the estimated $375 million cost, is now delivering Alberta natural gas to homes and industries in an area along its route encompassing three-fifths of the population of Canada.

Trans-Canada is serving 11 distribution organizations and the expected maximum day demand during the 1958-59 heating season is estimated at 263,400 m.c.f, compared with 195,800 m.c.f. daily sales estimated in 1956, and estimated Canadian sales of about 820,000 m.c.f. daily in the fifth year of operation.

The Alberta export permit under which Trans-Canada is operating provides for the removal of a total of 4.35 trillion cu.ft, of gas, at a maximum daily rate of 620 million cu.ft., and an annual rate of 210 billion cu.ft. The main suppliers of gas include B.A. Oil, Hudson's Bay Oil and Gas, California Standard, Canadian Delhi Oil, Provo Gas Producers, Home Oil and Canex Gas. This gas reaches the Trans-Canada line through the Alberta Gas Trunk Line Company's gas gathering system.

Trans-Canada is now delivering Alberta natural gas to cities and towns, homes and industries from Regina to Montreal. Sales contracts are in effect with Saskatchewan Power Corporation, Plains-Western Gas and Electric Company; Inter-City Gas Limited; Greater Winnipeg Gas Company; Northern Ontario Natural Gas Company; Consumers' Gas Company; Union Gas Company of Canada Limited; Lakeland Natural Gas Limited; Augusta Natural Gas; City of Kingston, Ontario; Quebec Natural Gas Corporation.

In addition to the approximate cost of $375 million for the building of the Trans-Canada Pipe Line system, the project sparked an industrial chain-reaction which will result in the spending of many billions of dollars.

Natural gas producers who supply Trans-Canada receive more than $650 million for their product; the producers will spend more than $200 million in the next few years drilling more wells and processing the gas; a new Alberta petrochemical industry based on stripping the byproducts from the gas calls for initial expenditures of $100 million; Alberta Gas Trunk Line will spend $60 million in construction; distributing companies along the route will spend approximately $200 million, extending present systems or building new lines; new pipe mills have required a capital investment of $50 million, other plants making valve assemblies, wrapping material and other pipeline requirements have invested $50 million—making a grand total of more than one billion dollars placed in circulation.

The new natural gas industry will have an immediate and important effect on Canada's adverse balance of international trade. For instance, in 1956 Canada imported coal from the United States valued at $130 million. The use of natural gas should reduce this dollar outgo by at least $40 million a year on the basis of the 1956 level of coal imports. In 1956 Canada paid $12 million for sulphur imported from the United States. By 1960 the sulphur recovered from Alberta natural gas will supply Canadian requirements and leave a surplus for export. Canada has been paying $12 to $15 million a year for imported natural gas. Almost all this gas has now been replaced by Alberta gas.

Some statistics of the pipeline:

More than 700,000 tons of steel required at a cost of about $150 million; contract construction costs, about $120 million; freight charges, $22 million; 43,000 railway carloads of pipe and other material; 8,930,000 cubic yards of excavation required in making the ditch; 530 miles of rock excavation; 13,700 miles of wrapping material for the pipe; 298 railway and highway crossings; 107 lake and river crossings; the pipeline carries the energy equivalent of four St. Lawrence seaway power developments.

Northern Ontario Natural Gas: Conversion work was completed in mid-November, and full-scale gas service from Alberta began in two mills of Abitibi Power & Paper Company Limited. At the Sturgeon Falls mill, natural gas will be used to fire mill boilers to produce steam for the manufacture of various types of board. In Iroquois Falls, natural gas will assist in the manufacture of groundwood, unbleached sulphite, newsprint and paper-board.

A total of 805 million cubic feet will be sold annually to the Sturgeon Falls mill. Total annual consumption for the Iroquois Falls mills is 2,359 million cubic feet. Both mills will burn gas on a dual-fuel basis, and retain previous heat source facilities. This enables mill boilers to switch from one fuel to another, on short notice, or to burn any desired combination of coal and natural gas.

Saskatchewan Power Corporation: Opened at a ceremony on October 30 the $10.5 million plant, first substantially sized plant of its kind in Saskatchewan for the processing of casinghead gas, is one of the most important conservation measures to be undertaken in the province. Initial rated capacity is 25 M. c.f.d., which can ultimately be expanded to 45 M. c.f.d.

St. Maurice Gas, Inc.: A proposed natural gas pipeline from Montreal to Quebec City would connect with Trans Canada just west of Montreal Island, pass through St. Hyacinthe and recross the St. Lawrence at Trois Rivières, then follow the north shore to Quebec. Three branches would serve St. Jean, Granby, Magog, Sherbrooke, Sorel and Drummondville. A branch east of Trois Rivières would serve Shawinigan. The proposed pipeline would be built by Cartier Gas Corp., at a cost of between $15 and $30 million. Cartier is seeking franchises in these communities — one such franchise has been obtained in Granby.

Alberta Underground Storage Ltd.: This Company, sponsored by B.A. Oil, Canadian Hydrocarbons and Goliad Corp. has been formed to develop underground storage for liquid petroleum gases near Hughenden, Alta. Most economical storage for large volumes of LPG liquids is the caverns in underground salt strata, after removing the salt by washing out with fresh water. Initial capacity would be some 150,000 barels. Ultimately 14 caverns would have a capacity of a million barrels.

Gas Products Pipeline Planned: Pembina Pipeline Ltd., is planning to build a 1200 mile pipeline from Alberta to the Great Lakes to market surplus natural gas byproducts. It would handle from 100,000 to 150,000 barrels of by-products daily. Estimated cost of the project approaches $150 million. Foothills Products Pipe Line Co. has applied to the Alberta Conservation Board for permission to export the by-products. The scheme involves a line to Lakehead or to Superior, Wisconsin, another to the Pacific Coast, or a combination of east and west routes. Processing plants would be located at the two terminals.

The Year 1958 Reviewed

Neil J. McKinnon, President, Canadian Bank of Commerce.

"It now seems likely that the Gross National Production (for 1958) will have a value fractionally above $32 billion, or about 2 per cent higher than in 1957", said Neil J. McKinnon, president of the Canadian Bank of Commerce at the ninety-second annual meeting.

"Allowing for higher prices the volume of production was probably little changed from the previous year. Our export trade has been well maintained, consumer expenditures have increased moderately and capital investment has shown but a moderate decline. For a year which began amidst gloomy forebodings this cannot be considered as other than a reassuring performance," Mr. McKinnon said.

A few of the characteristics of 1958 reported by Mr. McKinnon are these:

It now seems likely that a level of about $8.5 billion may be achieved in capital investment—a decrease of less than 3 per cent from last year.

A drop in capital expenditures for manufacturing is offset by an increase in expenditures for housing, which this year are estimated to reach an all-time high of more than $1.5 billion. Completions may amount to 153,000 units.

Aggregate consumer expenditure exceeded $20 billion for the first time.

There are indications that aggregate exports should come close to the level of 1957.

Industrial production, affected by domestic and foreign demand, emerged from its downward phase. Although volume has been adversely affected through industrial disputes it has, nevertheless improved to a level which, barring further work stoppages by now should compare well with last year. Mineral production has been adversely affected by less favourable foreign markets and prices but there are signs of improvement in some of its constituents.

Total value of mining production for the past year is expected slightly to exceed that of 1957.

Indications are that farm net income this year may prove to be slightly below that of 1957.

Although the work now going on in resource development is not as spectacular as that of a few years ago it is soundly based and undoubtedly we shall continue to see in the years to come a steady and important development of natural resources including the vital field of energy.

Hon. Gordon Churchill, Minister of Trade and Commerce, Canada

In a year-end review, The Hon. Gordon Churchill reports: "Considering the severity of the impact of . . . adverse influences from abroad, the pace of economic activity in Canada has been remarkably strong."

Some notes from the Minister's report are as follows:

On the basis of nine-month figures it appears that Canada's Gross National Product for 1958 will exceed $3 billion, 2 per cent above the figure of 1957. Prices on average have increased by almost the same percentage. Overall production in volume terms has equalled the level of the preceding year.

Employment has held up well and by the last quarter jobholders numbered about the same as a year ago. Industrial employment has been running moderately lower but this has been offset by a further filling out in service occupations. The labour force has grown at a slower rate this year, reflecting a level of immigration less than half that of 1957. Unemployment has been higher but the percentage increase from the same date a year ago has been narrowing sharply.

Despite conditions of ample supply in world-commodity markets, Canada's sales abroad have not followed the downward trend of world trade at large. They have remained at about the same level as 1957. Substantially increased sales have been achieved for several commodities including wheat, beef and uranium, farm implements. Reduction of industrial exports has been relatively moderate.

Imports into Canada are about 10 per cent lower in 1958 than in 1957.

The merchandise deficit for the first ten months was reduced to $242 million, from $733 million for the same period of 1957.

Capital spending plans at mid-year provided for outlays of $8.5 billion in 1958. Overall capital outlays for the year may fall but little short of the record $8,700 millions spent in 1957.

It is estimated that housing starts in 1958 will approach the 160,000 mark.

Another factor having an important sustaining effect upon general activity has been the high level of consumer spending supported by rising personal incomes.

Of the industries which had previously suffered a decline, most have experienced some degree of improvement by year-end. In aggregate terms the pick-up in production to date has been quite moderate. There is, however, strong indication of further expansion in market demand. Reflecting this improvement and contributing to it is the fact that inventory liquidation is now coming to an end, though conditions vary from one trade to another.

In recent months new capital expenditure plans have been appearing in increasing volume.

What Goes On

New Asbestos Mill

A $36 million mining and milling operation at Black Lake, Que., will contribute approximately 10 per cent of Canada's production of asbestos and 7 per cent of the free world's supply. It was formally dedicated in October 1958.

Owned and operated by Lake Asbestos of Quebec Ltd., a wholly-owned subsidiary of American Smelting and Refining Company, the operations are expected to yield 100,000 tons of asbestos a year for at least twenty years, from open pit mining.

In the course of construction, Black Lake was shifted to a new basin, a river was diverted into a new channel, four dams were constructed. The asbestos deposit was at the lake bottom, under 27 million cu. yd. of mud and silt.

The 9-million mill, houses ultra-modern equipment to free asbestos fibre from the ore, and to grade, dry, and prepare fibre for shipment.

Saskatchewan Developments

A trial run at the Potash Company of America Plant near Saskatoon saw the first large extraction of potash ore come above ground from the mine workings some 3,300 feet underground. This was the first time potash has been mined in Canada. The first commercial rail shipment was to leave the plant in December.

First production of polyethylene flexible pipe rolled off the assembly line at the Weyburn plant of Western Wire and Cable Co. Ltd., in November.

A 15-million basic steel industry will be established north of Regina. Inter-provincial Steel Corporation Ltd., with president J. W. Sharp, will equip the new plant for 100,000 tons per year capacity. Completion is planned for the end of 1959.

British Columbia Power

British Columbia's economy will be bolstered in 1959 by $95,800,000 expansion program announced in December by B.C. Electric.

Biggest single expenditure during the year will be $22,400,000 for work on the second-stage development of the Bridge River hydro-electric project.

This project will provide 345,000 horsepower of additional electric generating capacity before 1961 to meet growing power demands. Total cost will be $56,500,000.

Another $18,100,000 will be spent in 1959 on the Burrard steam plant now under construction on the north shore of Burrard Inlet, near Ioco. This plant will have a generating capacity of 800,000 h.p. from four generating units before 1965. The plant is designed for a possible ultimate capacity of 1,200,000 h.p.

The gas turbine electric generating plant at Port Mann, just east of New Westminster on the south bank of the Fraser, will be completed in 1959. Expenditure during the year on this 134,000 h.p. plant will be $2,100,000.

Month to Month

News of the Institute and the Profession

COMMENT
CORRESPONDENCE
ELECTIONS
AND TRANSFERS

CONFEDERATION—A Progress Report

Following the recent practice, Dr. I. R. Tait, chairman of the Institute's Committee on Confederation made a progress report to the December meeting of the Council. The following report to the membership is based on Dr. Tait's report.

The hope was expressed in the November account that the report of the sub-committee would receive the approval of all members of the Joint Committee. This hope has been realized. Council has been advised that complete unanimity of approval has been received from all fifteen members of the Joint Committee. Not one suggestion or request for a change has been received. On the contrary every member of the committee has sent with his approval his congratulations to the sub-committee for their excellent report.

The committee now is ready to take the next step, i.e., submit the report to the two councils for their approval and for the subsequent referral to the members at large.

Council has arranged for a plenary meeting to take place at Toronto on Saturday January 31, at which councillors will have an opportunity to express their opinions.

A copy of the report and supporting documents is being mailed to each councillor so that he will have time to study it carefully before the meeting at which approval will be asked.

It was recommended by the committee that if the two councils approve the report, they should then submit it to their memberships with a ballot asking for their approval or otherwise. The Council of the Institute agreed to the recommendation. The Canadian Council have not yet had an opportunity to meet to discuss it but will do so shortly.

Confederation has surely moved a long way towards becoming an accomplished fact. There is still a long way to go and care must still be taken to make sure that each step is a safe one, but with the emergence of the committee's report, it is evident that the principal obstacles have been surmounted. Shortly the decision will be in the hands of the members themselves.

Anniversary for Structural Engineers

The Institution of Structural Engineers of Britain celebrated fifty years of service at a jubilee meeting October 7 to 10, 1958.

Ben O. Baker, M.E.I.C., of Quebec, Que., councillor of the Engineering Institute, represented the Institute at the meeting and conveyed greetings to the Structural Engineers.

He attended the dinner given by president-elect G. S. McDonald, as one of twenty-three guests from many parts of the world. He also attended the annual banquet and ball, at which there were well over eight hundred present.

Mr. Baker reported on his discussions at the council meeting in November, and he presented a copy of the Jubilee Issue of *The Structural Engineer*, Journal of the Institution, for the use of the E.I.C. Library. He also presented to the Library a set of preprints of the papers given at the Jubilee Meeting. Their titles are listed

Ontario Agricultural College Receives the President

Dr. Kenneth F. Tupper, president of the Engineering Institute was a visitor to the Ontario Agricultural College, Guelph, recently, when he addressed the engineering students and staff on "The Role of the Engineer in the Development of Canada".

Engineers who gathered at the College for the occasion are seen in the photograph: left to right: A. H. Austin, of Armco Drainage, Guelph, secretary-treasurer of the Kitchener Branch E.I.C.; Dr. Garnet T. Page, general secretary; Dr. J. D. MacLachlan, president of the Ontario Agricultural College; Dr. Tupper; Prof. C. G. E. Downing, head of the O.A.C. Engineering Science Department; and L. J. R. Sanders of Galt, councillor of the E.I.C.

on Page 000 of this issue. There were three Canadian papers on the program.

President of the Institution during the Jubilee year was Professor Sir Alfred Pugsley. Secretary during the past twenty eight years has been Major Reginald F. Maitland.

Nominees for Office

Engineering Institute of Canada

A list of nominees for office, as reported by the Nominating Committee, appeared on page 102 of the October 1958 issue of the *Journal.* Since that time the committee has reported the selection for president as follows:

President .... John Jeffery Hanna .... Calgary, Alberta

E.I.C. Technical Conferences in 1959

Regional Meetings

A growing interest in regional technical meetings was seen during 1958. This year there will be still greater opportunity for E.I.C. members to take part in this important activity, with four regional meetings planned by the branches.

The *Journal* will publish advance information about these conferences, as well as programs and reports. There are a few corrections to be made to the list which was included in the November and December issues.

The Second Southern Ontario Regional conference, to be held in Hamilton, Ont., on March 14, with six branches participating, is advertised on this page. E. W. Hill, M.E.I.C., is general chairman of the Conference Committee.

A Technical Conference is tentatively planned for May at Sudbury, Ont.

The Western Regional Technical Conference, to be held at Banff, Alberta, October 2-3, 1959, will provide a good program including a forum on drainage and irrigation. W. A. Smith, M.E.I.C., of Calgary, is chairman of the Conference Committee.

The Ottawa Regional Meeting will mark the 50th anniversary of the Ottawa Branch. The dates for this conference are October 15-16, 1959, and *not* October 18-19, as previously listed.

Annual Meeting, 1959

Good progress is also being reported on the technical program of the 1959 annual meeting: June 8-10, Toronto, Ont.

The *Journal* will have advance information about the annual meeting in every issue.

Chairman of the annual meeting committee is E. R. Davis, M.E.I.C., of Toronto.

Don't Miss The

SECOND E.I.C.

SOUTHERN ONTARIO REGIONAL CONFERENCE

Where: Sheraton-Connaught Hotel, Hamilton.

When: Saturday, March 14, 1959.

Program: Noon Luncheon — Panel: "Engineer — 1965"
Afternoon: Engineering Papers — Reception and Cocktails —
Dinner and Guest Speaker — Conference Ball

For the Ladies: Luncheon and Fashion Show

YOU made last year's Conference such an outstanding success that the 1959 Conference should be even better.

All EIC and APEO members and their ladies are cordially invited.

PARTICIPATING BRANCHES;

London Kitchener Border Cities Niagara Peninsula

Toronto Hamilton

Watch for details; Plan now to attend

Elections and Transfers

On the recommendation of the Admissions Committee a number of applications were presented for consideration to the meeting of Council for December, and it was agreed that the following elections and transfers become effective:

Members: F. Csete, Montreal; C. L. Evans, Toronto; N. Freight, Edmonton; S. P. Hauck, Edmonton; M. A. Lazarovici, Calgary; A. J. G. Leighton, Victoria; A. B. Maslin, Galt; T. O. Orr, Montreal; R. E. J. Putman, Toronto; W. C. Seaforth, Toronto; P. H. Stewart, Montreal; C. Szoo; Montreal; P. S. Szypulin, Montreal; A. C. Tait, Toronto; J. A. van der Giessen, Vancouver; A. A. Waters, Toronto; F. J. Winterburn, Baie Comeau.

Juniors: A. Jex, St. Catharines; K. Nyhus, Drumheller; J. H. Pitts, Niagara Falls; R. J. Rhodes, Montreal.

Affiliate: P. R. Gendron, Ottawa; A. T. Johnstone, North Bay; A. La Bissonniere, Montreal; A. G. MacAulay, Montreal; O. G. Moffat, Hamilton.

Junior to Member: S. G. Frost, Ottawa; G. Gow, Liverpool, N.S.; J. H. Legere, Montreal; A. M. Mackay, Cochrane; G. H. Milne, Fort Erie; T. E. Pelton, Vancouver.

STUDENTS ADMITTED

Queen's University: F. L. Anderson; R. Arcand; M. Backa; S. Backa; D. B. Bailey; D. A. Barrington; W. J. Barrott; W. R. P. Blackwell; R. M. Borne; J. H. Boyle; R. J. Brabbs; J. E. R. Brankley; J. G. Brics; G. J. Brinkmeier; J. C. Brownell; J. C. Bunge; C. D. Byrns; B. L. Calder; J. J. Cameron; R. K. Campbell; G. F. F. Carscallen; W. J. Clark; H. R. Clarke; D. T. Cole; D. M. Coulson; W. A. Crago; W. R. Darker; W. A. Davis; J. W. Davison; C. J. Demeyere; J. H. W. Diamond; W. R. Dormer; N. A. Douglas; G. R. Dowden; K. G. Dunn; D. G. Durant; A. E. Earl; W A. Este; W. A. Evans; A. R. Ferguson; J. D. A. Ferguson; E. Farankovich; W. R. Fraser; R. J. Geddes; A. W. Gilliland; J J. Gribbon; C. R. Grubb; K. M. Haapanen; D. E. Halliwell; D. E. Haws; J. A. Hayes; J. E. M. Henderson; W. A. Henwood; R. S. Hicks; E. A. Hopkins; W. A. Jaruis; W. T. Jenkins; R. E. Johnston; N. L. Journeaux; J. N. Kendall; J. Kiuru; L. O. Koskitalo; A. S. Krausz;
C. Lal; B. D. Lamorie; J. G. Lawrence; R. L. Levasseur; G. G. Liesemer; J. T. Lightall; D. G. MacDonald; G. A. MacIntosh; J. H. MacKay; D. M. MacKenzie; J. C. McBean; W. R. McBride; R. L. McCabe; J. T. McDermott; S. C. McEachern; W. G. McGill; A. S. McIntosh; J. D. McLeod; A. C. Machin; J. V. R. Manning; E. E. Marcellus; G. F. Marsters; R. E. Marttila; S. A. Meer; J. R. Mills; R. A. R. Mills; M. E. D. Misner; M. Moziar; M. S. Myint; E. J. N. Niceforo; G. A. Nicol; D. A. Norman; D. H. O'Hara; L. F. Organ;
M. A. Pe; G. D. Pearson; W. M. Porobich; D. L. Pratt; J. S. Pritchard; W. R. Purdy; H. A. Redstone; E. R. Richardson; K. S. Roberts; K. W. Ross; K. Roth; J. E. Sexton; G. V. Sherwood; K. W. Sinclair; J. C. Singlehurst; G. J. Splinter; R.. R. Stucky; D. G. Tate; R. R. Tinline; R. H. Townsend; D. R. Turnbull; G. D. Vallee; W. E. Watt; H. T. A. Webster; L. E. Wells; M. K. Win; H. C. Wood; H. A. Woodgate; A. Yuchimenko.

University of Manitoba: R. D. Adams; R. R. Adamson; E. W. Anderson; R. Billinton; J. I. Bogdonov; A. A. Borger; C. W. Bright; D. W. Brown; D. G. Buchanan; J. D. Buchanan; R. J. Chase; W. R. Cooke; W. L. Cox; R. L. Curtis; D. Demedash; D. Duncan; D. A. J. Ennis; P. N. Feschuk; R. B. Finlay; J. G. Fisher; R. K. Forbes; T. R. Fox; R. D. Hamilton; R. A. Hay; W. G. Herrod; H. L. Hiley; S. S. Hodge; F. N. Houston; R. M. Hovey; R. M. Jell; R. J. Johannson; B. Klewchuk; S. J. Kustra; D. F. Lamb; J. N. Lewak; G. B. Little; J. G. Locker; A. C. Mackey; S. C. MacPherson; J. Mar; D. B. McKenzie; R. R. McKibbin; W. Miller; L. A. Morison; W. E. Muir; L. R. Nichol;
L. F. Pedrick; K. N. Posgate; G. A. Pratt; B. W. Prentice; J. D. Rathgeber; H. L. Rawn; B. Reid; W. A. Reid; D. Reitlo; J. F. Russell; R. R. P. Schriber; G. Schultz; D C. Sexton; J. H. D. Smeaton; W. Smitiuch; T. J. M. Sopchuk; S. Soudack; D. K. Strang; G. Tarapasky; R. H. R. Tide; A. J. Watts; B. C. Weir; W. A. R. Whitcomb; H. R. Wilcox; D. J. Wilson; W. P. Wolfe; R. R. Zimmerman.

University of Ottawa: G. Archer; M. Bastien; M. L. Bedard; C. Bolduc; M. J. G. Boucher; J. H Bousfield; J. L. Bouvier; G. C. J. Bradette; R. T. Brown; J. E. Brunet; G. Campbell; A. J. Cataford; B. J. M Cataford; W. H. Y. Cheh; R. Cleroux; M. Concil; M. Cossette; J. M. Fournier; J. N. Falardeau; J. Fernandez; A. W. J. Galipeau; P. R. Gareau; G. Garneau; R. Gaudreault; P. Gauthier; G. M. R. Girouard; P. Gravel; R. E. Hansen; D. M. Harris; L. Huard; P. Hubert; D. J. Kyriazis; L. F. Landry; R. Larocque; D. Layton; M. Leeviraphan; P. A. W. Keon; V. Kui-Dick Li; R. A. Lord; Y. P. Lum;
N. J. McKay; J. P. B. Mangione; J. L. Mathieu; J. Michaud; J. M. C. Morency; R. G. Morris; A. Paldi; A. Paradis; M. Patenaude; J. R. Plaxton; G. R. Quarrington; E. D. Rainboth; L. M. R. Rehel; R. L. Robinson; J. Rousseau; J. P. Roy; P. Sanscartier; A. O. Sauolainen; A. Selin; S. D. Shaffer; J. T. Shilhan; G. A. Smith; M. F. Smith; J. G. Soulard; R. J. Turkevich; F. C. Van Der Pryt; K. P. Wong.

Loyola College: C. M. Archibald; H. Backman; T. F. Bagg; F. P. Brais; R. P. Czarnecki; R. Dechene; J. J. G. M. Desaulniers; M. B. Goruk; N. Hornyak; J. W. Houghton; A. B. Hurtubise; T. Kobelansky; J. G. Lavoie; J. H. Le Cornec; P. D. Maguire; P. E. Mayers; C. E. Ohlson; J. Osman; R. S. G. Piedalue; D. P. Rannie; M. St. Onge; J. A. Sinclair; P. A. Tetro; E. M. Traczyk; A. Turmaine; J. C. Verby; I. E. Williams.

University of Toronto: B. M. Addison; D. J. Condos; L. L. Davis; J. A. Deakins; J. H. Fine; D. S. Frost; G. W. Haessler; G. E. Holmes; M. E. Hoshkiw; H. S. R. Judges; F. E. Krueger; B. P. Leschuk; R. R. McCleary; D. A. McTavish; A. B. Nicholson; R. T. Orlando; J. A. F. Roberts; T. B. Roberts; W A. Travnik; E. L. Umbrico; D. L. Valentine.

Nova Scotia Technical College: D.A. Church; F. J. Corcoran; J. P. Corcoran; J. A. Fowler; G. J. Greer; E. C. Gregoire; J. A. Hopkins; F. J. Kelly; J. D. Kelly; R. M. Lane; D. F. MacLennan; J. W. Ricketson; V. R. Savoie; H. E. Slaunwhite; F. M. Swanter; R. J. Wong.

Ontario Agricultural College: M. D. Brown; K. G. Edwards; A. B. Hall; G. J. Harvey; J. D. Horwood; W. A. Johnston; A. M. MacKenzie; D. H. Patterson.

Sir George Williams College: C. F. Farnworth; F. Fiksel; S. F. Pressoir; D. Sicuso; S. Slawner; H. J. M. Van Der Staay; R. O. Wills.

University of Sherbrooke: J. Demers; R. Dion; S. Lacroix; C. Mercier.

Dalhousie University: J. H. Hayward; R. M. Ritcey.

St. Dunstan's University: B. A. Gallant; C. H. White.

University of Alberta: E. G. Hrdlicka.

Mount Allison University: J., E. V. Foster.
McGill University: — A. C. Niderost.
Graduates: M. R. Ernesaks (B.S.Sc., civil, Toronto 1958); S. J. Smith (B.A.Sc., mech., Toronto 1958); J. J. Qualters (B.Sc., Loyola 1958).

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Association of Professional Engineers, the following elections and transfers have become effective:

ALBERTA

Member: R. G. Durward; **Junior:** M. M. Andrews; **Junior to Member:** T. Covello.

SASKATCHEWAN

Members: C. R. MacPhail; M. P. Nicholaichuk; C. A. Noble; A. Porter. **Juniors:** R. N. Filson; D. J. Nevill. **Junior to Member:** N. E Cressey; A. A. Roesch; H. Schmidt; **Student to Member:** M. E. Famulak.

CORRECTION

Edward M. Bates, Winnipeg. Man.: incorrectly reported in the March 1. 1958 minutes as Member, should have been listed as Junior.

STUDENTS: E. A. Anderson; P. P. Balasch; H. D. Barber; F. T. A. Barlage; H. J. Bell; L. P. Benoit; J. F. Betemps; B. C. Beveridge; B. Breadner; V. B. Brown; R. R. Bryce; A. Charnish; E. A. Cochrane; J. R. Connell; W. J. Cooke; W. W. Crossley; W. R. Demetrick; L. Dinter; J. Ens; J. S. Farley; L. D. Federspiel; E. W. Filipowich; L. Flaman; D. P. Flathman; S. T. Flett; B. J. Foster; C. B. Foy; R. G. Glencross; R. G. Gorrill; O. J. Green; J. H. Hamilton; J. M. Hamilton; R. S. Hamilton; W. J. Harder; T. D. Harle; F. R. Hill; R. O. Houston; W. M. Hunter;
R. N. Jacobs; F. W. Jamieson; L. E. Johnson; T. W. Johnston; A. W. Kempthorne; M. G. Korol; D. J. Kot; A. E. Kovach; E. O. Kozey; J. W. Kramer; L. H. Lashyn; T. S. Lau; G. A. Ledingham; T. D. Lee; D. H. Linn; D. G. MacLennan; A. L. MacMillan; J. R. McClement; K. E. McCullagh; W. J. McDonald; D. J. McKay; W. W. McKinnon; P. Machibroda; C. P. Mah; D. V. Makuch; E. C. Mikulcik; R. M. P. Miller; J. L. Milne; H. J. Murzyn; D. D. G. Nunweiler; J. O. Ochitwa; W. E. Olauson; A. L. Opseth; H. W. Orr; E. G. Popadynic; M. L. Parsons; D. A. F. Park; W. C. Paynter; P. Pisio; P. P. Pospisil; C. A. Reed; G. K. Rever; R. J. Reynolds; J. E. Richert; K. J. Rieder; L. I. Riess; G. W. E. Roach; G. K. Robinson; K. N. Rockel; C. J. Runolfson;
A. P. Sander; R. G. Sanders; G. R. Schell; A. J. Schwinghamer; D. L. Sedgwick; T. J. Seymour; B. A. Sjoberg; G. C. Skorobohach; D. R. Smith; G. C. Sollid; W. Spak; B. J. Stolee; M. P. J. Swanston; J. K. Theil; W. F. Thiele; L. E. Trickey; G. H. Turnbull; J. W. Ulrich; E. W. Unick; A. M. Veroba; J. K. Walker; H. J. Wasylyk; D. D. Warner; N. P. Weber; H. T. Welch; L. D. Westgate; J. N. Wilson; W. J. Wishlow; G. W. Wortman; J. T. Wright; M. Yamakami; G. R. A. Zieglgansberger; J. G. Zbeetnoff.

French Government Scholarships

Several thousand foreign students are working in French institutions, universities and laboratories. The number of engineering and technical students, in particular, has greatly increased since the war. It has become necessary to organize and coordinate formal courses and practical work. The French Government has created a service to this end (Service de Cooperation Technique) and has endowed a great many scholarships, a number of which have been reserved for Canadian engineers or technical men.

Value of grants includes: as much as 75,000 francs a month for the standard period of six months; free return trip from France to Canada; free transportation in France for authorized trips; privileges normally reserved to University students, to the extent available (lodging and restaurant facilities, community activities, libraries, lectures, etc.); allowances for the purchase of technical books and for the cost of typing final reports.

Prompt action is suggested. Before filing a formal application, which must be made on an official form and accompanied by several detailed documents, a simplified procedure is suggested, namely, that you *write immediately a letter covering as briefly as possible the following points:* Name, address and telephone number; date and place of birth; Academic training or equivalent, (specify degree and specialty) and class ranking; practical experience; references (give name and telephone number of two persons); knowledge of French; program and duration of proposed "stage" in France.

This letter should be addressed in triplicate to: Mr. Raymond TREUIL, Chairman of the Comite France-Technique, c/o French Embassy, 464 Wilbrod Street, Ottawa, Ontario.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

Frank P. Moran, JR.E.I.C., of the B.C. Forest Products, Vancouver, B.C., died on May 3, 1958.

Born at Burnaby, a suburb of Vancouver, Mr. Moran attended the University of British Columbia and graduated with B.A.Sc. degree in mechanical engineering from that institution in 1951. Employed with the B.C. Forest Products since his graduation, Mr. Moran designed and was responsible for the building of an all steel mobile spar tree. The prototype of this proved very successful. Mr. Moran was at the time of his death engaged in making minor improvements on this work.

Mr. Moran joined the Institute as a Student Member in 1948, transferred to Jr.E.I.C. Membership in 1953.

Professor G. V. Douglas, M.E.I.C., retired geologist, died on October 8, 1958 in Toronto. George Vibert Douglas was born in Montreal on July 2, 1892. He began his engineering career while serving with the Northumberland Fusiliers, and the Royal Engineers, during World War I. Discharged with the rank of captain, he was one of those selected to receive a Military Cross in 1918. Returning to a civilian status Mr. Douglas pursued his formal education at McGill University and graduated with B.Sc., and M.Sc., degrees in mining and geology from McGill University in 1920 and 1921.

In the next two years Professor Douglas had the opportunity to take part as geologist on the Quest, R.Y.S., which was Sir Ernest Shackleton's expedition to the Antarctic. After two years as assistant professor at Harvard University he was appointed chief geologist to the Rio Tinto Mining Company in Spain, later in Northern Rhodesia. The newly established Carnegie Chair of geology at Dalhousie University, N.B., was offered him in 1932. He accepted the appointment and gave twenty-five years to the advancement of geological interest and studies at the University.

Through his lectures to a wide range of audiences and through the Dawson Geological Club, which he founded in 1933, he made geology come alive. After his retirement from Dalhousie University in 1957 he lectured at the Extension Department, University of Toronto and carried on geological consulting work.

Professor Douglas joined the Engineering Institute of Canada as a Junior member in 1920, transferred to Associate Member in 1921, and to Member in 1940. He became a Life Member of the organization in 1957.

Wilfred S. Lawson, M.E.I.C., retired chief engineer, Department of Justice, penitentiaries branch, died on September 23, 1958.

Born at Barnsley, Yorkshire, on November 27, 1880, Wilfred Stelm Lawson attended Yorkshire College, Leeds, England. Joining the Canadian Pacific Railway on his arrival in this country in 1903, he worked with the Temiskaming and Northern Ontario Railway and the Canada Foundry Company, Toronto, for the first few years. With the latter firm he became assistant engineer, assistant bridge engineer with the National Transcontinental Railway, bridge department, 1913, and acting bridge engineer, 1915. He also served the Canadian Army for several years, retiring with the rank of major. Later a bridge engineer with the Canadian National Railway Company, he left the organization to accept an appointment as a bridge instructional engineer with the Department of Railways and Canals, Government of Canada, in 1921. A year later he was transferred to the work of structural engineer, Penitentiaries Branch of the federal government. Named chief engineer of the Branch in 1928, he retained this responsibility until his retirement in 1947. During World War II he took over the duties of acting superintendent of penitentiaries, with the award of an O.B.E. in 1946.

Mr. Lawson was a member of the committee of the Ottawa Branch of the Engineering Institute of Canada which was responsible for the erection of the Colonel By Memorial in Ottawa.

Mr. Lawson joined the Engineering Institute in 1907 as an Associate Member. He transferred to the status of Member in 1916, and attained Life Membership in 1942.

Lt. Col. Robert Bickerdike, M.E.I.C., of Montreal, retired consulting engineer died on November 8, 1958.

Robert Bickerdike was born in Montreal on September 30, 1869. He was educated in Montreal schools and at McGill University. He was awarded a B.A.Sc. degree in civil engineering in 1891, and an M.Eng. degree in 1895. While yet a student he was engaged in work as an assistant on surveys for the location of the Vaudreuil and Prescott Railway, afterwards known as the Montreal and Ottawa Railway. His first graduate work was as an assistant engineer in charge of the McGill College Observatory.

During the next few years he worked with the United Counties Railway, the Atlantic and Northwestern Railway, the Drummond County Railway, and the Montreal Harbour Works. He was a demonstrator of surveying at McGill University for a time; and was later associated with the Department of Public Works, the Department of the Marine, Province of Quebec, and the National Transcontinental Railway.

Colonel Bickerdike was employed in construction work for the Canada Starch Company at Fort William and Cardinal, Ontario, before the first World War.

Active in the militia at that time, he was involved in the work of recruiting. He went overseas and saw lengthy overseas service in France, winning the D.S.O. and Bar. He returned to Canada in command of the 87th Battery and on demobilization was transferred to the Royal Montreal Regiment. He was transferred to the Reserve Army in 1920. He carried on his consulting practice in Montreal for many years.

Lt. Col. Bickerdike joined the Institute as a Student in 1888, became an Associate Member in 1895 and a Member in 1900. He attained Life Membership in 1936. He was also a member of the Institution of Civil Engineers.

John Samuel Hunter, M.E.I.C., of Calgary, president and general manager of Hunter Drilling Limited, was killed in a plane crash, October 8, 1958.

Born in Metronne, Sask., on December 25th, 1921, he attended the University of Saskatchewan, obtaining a B.Sc. degree in civil engineering in 1948.

His career began with the Canadian Pacific Railway Company in the post of junior draftsman in 1947. Receiving his degree, the following year he became senior transitman, then operating assistant. Mr. Hunter left the Canadian Pacific Railway in 1957 to join Seaman Engineering and Drilling Company Limited as general manager. A year later he acquired the responsibilities of president and general manager of Hunter Drilling Limited.

He joined the Institute as a Member in 1957.

Lt. Col. R. Bickerdike

G. V. Douglas

NEWS OF THE
Associations and Corporation

Information received through co-operation of the provincial organizations.

QUEBEC

(From the Bulletin of the Corporation of Professional Engineers, December, 1958.)

New Report Features Actual Salaries

Actual rather than recommended figures and a series of job levels instead of grade definitions are the more apparent features of the "Report on Salaries of Professional Engineers by Levels of Responsibility", published in September. This Report supersedes the "Schedule of Salaries" which was last issued in June, 1957.

The Report is a factual account of salaries paid 6,309 professional engineers by 92 industrial and other organizations in Ontario and Quebec as of July 1st of 1958. The survey was conducted by the Quebec Corporation and the Ontario Association. The organizations approached in the survey were asked to identify the work performed by the engineers in their employ with a number of descriptions of typical engineering jobs. It was necessary that the positions match the descriptions and the appropriate responsibility level.

The elaborate level descriptions in the Report make it easier to match a given job. In addition, more emphasis has been placed on the extent of responsibility and the reference to the number of years of experience is only incidental.

ONTARIO

From *The Professional Engineer*, November, 1958, an abstract.

Five Needs of The Professional Engineer, by J. Herbert Smith, D.Sc., P.Eng.

As I see it, the primary distinction between the professional man and the skilled technician is the *perspective* developed in the professional man as a result of the academic discipline of his training. This perspective not only allows him to see his own contribution as an important integrated part of the whole economic and social structure, but demands for his personal satisfaction and development that his work can be so seen by both himself and his associates.

The problem management faces is to identify the specific needs that must be satisfied if the professional employee is to be an effective and productive member of the enterprise.

Summarized then, these are the five specific needs of the professional engineer that must be satisfied by the design of his job:

(1) He must have professional work.
(2) He must have opportunities for promotion as a professional employee and individual contributor.
(3) He must have financial incentives as a reward for improved performance and greater contribution as an individual contributor.
(4) His job must be supervised from a professional viewpoint.
(5) He must have professional recognition both inside the enterprise and the larger community.

BRITISH COLUMBIA

Annual meeting

R. E. (Ron) Wilkins, O.B.E., P.Eng., was elected president of the Association for the coming year. Results of the ballot were announced at the Saturday luncheon of the annual meeting held in the Empress Hotel, Victoria, on December 5 and 6. New vice-president is H. P. J. Moorhead, P.Eng., and elected to membership on Council were R. S. Cunliffe, P.Eng., (Civil); Frank Noakes, P.Eng., (Electrical); H. M. Wright, P.Eng., (Metallurgical); J. R. Giegerich, P.Eng., (Mining); and William Hall, P.Eng., (Forest). The remaining four members, to be nominated by the Provincial Government, were to be named by Order-in-Council early in the new year. Immediate past president, George C. Lipsey, P.Eng., will continue to serve, ex-officio, for another year.

R. E. Wilkins, P.Eng.

Two hundred and seventy-five members, and seventy-five visiting wives checked in at the reception desk during the two day session.

Guest speaker at the annual luncheon on Saturday was Dr. Brock Chisholm, C.B.E., former director-general of the World Health Organization. Speaking on "Our Increasing Responsibilities", he stressed the fact that two thirds of the world's people are suffering from lack of food. He stated that starvation, through improper distribution of food, is an even greater danger than the peril of suicidal war. Contributing to this danger is nationalism in every form, and it becomes necessary for survival to develop a maturity that will make it possible for all of us to function as members of the whole human race, regardless of our upbringing or place of birth, he concluded.

A new function this year was a reception for the deputy ministers of the Provincial Government.

On Friday evening a highly successful stag party was held in the Pacific Club when the annual barbershop harmony duel for the Killam Kwartet Kontest Kup — the only plush bottom copper plated grease cup in the world — was won by a quintet composed of A. C. Dalrymple, P.Eng., G. Griffiths, P.Eng., J. W. Milligan, P.Eng., F. R. B. McLean, P.Eng., and S. P. Oakes, P.Eng.

On Saturday evening the ballroom of the Empress Hotel was crowded to capacity by 340 of the members and their wives for the annual banquet and dance.

The fifth annual Awards Luncheon was held on Friday, when some 35 recently registered members received their certificates. Life Membership medallions were also presented to T. H. Crosby, P.Eng., H. J. MacLeod, P.Eng., W. I. Nelson, P.Eng., J. I. Preissner, P.-Eng. and C. E. Scanlan, P.Eng.

The Letson Memorial Prize for the best report on mechanical engineering was presented to Norman H. Booth, P.-Eng., of Trail, by G. M. Letson, P.Eng., on behalf of his brother. A signal honour was paid to R. W. Diamond, P.Eng., when the members approved a recommendation of Council and granted him an Honorary Life Membership for his distinguished contribution to the Association and to engineering in general.

Personals

News of the Personal Activities of Members of the Institute

C. E. Campeau, M.E.I.C. (B.A.Sc., Ecole Polytechnique 1941) former director of the City Planning Department of Montreal, is practising as a consulting engineer and consulting town-planner in Montreal. He is the Member of Parliament for Montreal-St. James, Montreal.

Jos. A. Grant, M.E.I.C., (B.A.Sc., mining, Toronto 1942) has retired as consulting engineer in Montreal and is permanently residing at Dewittville, Que.

Mr. Grant was associated with highway, airport, and building construction across Canada for many years. He was employed by the Sheraton Corporation in Canada and the United States in recent years.

Ernest A. Leja, M.E.I.C. (chem., Latvia 1930) managing director of Lundrigan's Concrete Limited in Corner Brook, Newfoundland, holds office as chairman of the Engineering Institute's branch in that city.

W. H. Eastlake, M.E.I.C. (B.A., Toronto, 1912) has retired as general manager of the wire and cable division of Northern Electric Company Limited, Montreal.

Joining Northern Electric before World War 1, he was on leave of absence, 1915 to 1918, with the British Munitions Company Ltd. After the war he returned to the company and in 1933 was appointed assistant general superintendent of the wire and cable division. He became works manager in 1938, manager in 1945 and general manager in 1953. He is a Life-member of the Institute.

Prof. D. G. Huber, M.E.I.C. (M.A.Sc., mech., Toronto 1942; Ph.D., Iowa 1948) associate professor of the mechanical engineering department at McMaster University, Hamilton, has been elected chairman of the department. He was with the University of Toronto previously, as assistant professor of mechanical engineering.

H. H. Moor, M.E.I.C. (M.A.Sc., chem., Toronto 1923) has been appointed deputy management development counsellor of Imperial Oil Limited in Toronto.

With 35 years of service with Imperial Oil, Mr. Moor is a former manager of the Edmonton refinery, and recent manager of the refinery at Imperoyal, N.S. He supervised the expansion in Nova Scotia, completed in 1957.

A. H. W. Busby, M.E.I.C. (B.Sc., mining, Birmingham, England, 1923) has been named consulting mechanical and electrical engineer for the Rhodesian Section, Anglo-American Corporation of South Africa Limited. In Canada, he was associated for many years with the Consolidated Mining and Smelting Company, Trail, B.C. He was superintendent of engineering research and development for the company from 1946. He went to Rhodesia in 1954.

Murdo MacLeod, M.E.I.C. (B.Sc., chem., Alberta 1933) former plant superintendent of Imperial Oil Limited's Imperoyal Refinery, has become manager of the refinery. Mr. MacLeod has an extensive service with the company in Calgary, Regina and Toronto. He went to the Imperoyal refinery in 1948.

R. I. Stevens, M.E.I.C. (B.Sc., elec., McGill 1935; M.Sc., elec., McGill 1936) works engineer at the chemicals plant of Canadian Industries Limited at Shawinigan, Que., has become supervisor of the company's ammonia works at Millhaven, Ont. He joined the company in 1939, and was for several years at Windsor works.

Z. C. Van Schwartz, M.E.I.C. (M.S./M.E., mech., Northwestern University, Valparaiso, Chile, 1932) has been appointed management consultant of C. A. Norgren Co. & Affiliated Companies, Denver, Colorado. His previous occupation was director, engineering, manufacturing, standards of Baldwin-Lima Hamilton Corporation, Hamilton, Ohio.

R. S. Segsworth, M.E.I.C. (B.A.Sc., mech., Toronto 1935) has accepted a post as assistant to the general manager of Ajax Electrothermic Corporation, Trenton, New Jersey. He was formerly associated with the General Engineering Company, Toronto in the research and development branch.

Eric C. Smith, M.E.I.C. (B.Sc., civil, Leeds, England, 1949) has joined Atomic Energy of Canada Ltd. as civil design engineer in the nuclear power plant division. He was formerly associated with the Hydro-Electric Power Commission of Ontario, Toronto.

W. B. Thomson, M.E.I.C. (B.Sc., civil, Saskatchewan, 1942), has been appointed a construction engineer for the South Saskatchewan river project, with headquarters at Regina. He was previously working on the St. Mary Milk River project, at Lethbridge, Alta.

Mr. Thomson resigned, due to this move, as chairman of the Lethbridge Branch, E.I.C. He had been a member of the executive for several years.

C. E. Campeau

E. A. Leja

H. H. Moor

Z. C. Van Schwartz

R. S. Segsworth

The 3,071ST Bridge

New Rivière des Prairies bridge, near Montreal, incorporates ten 225 ft. girders, each 70 tons; twenty of 212 ft. and many of smaller size.

• PERSONALS

A. P. Wiles, M.E.I.C., (B.Sc., engineering and physics, Saskatchewan, 1946), formerly with Ford Motor Company of Canada as research engineer, is presently employed by the R.C.A. Victor Company as a systems engineer in the new defense systems division.

John L. Aikman, M.E.I.C., (B.Eng., mech., McGill 1950), chief engineer with Thurso Pulp and Paper Co., Thurso, Que., is working as shift engineer at Montreal Children's Hospital.

Lieutenant Commander M. R. Kent, M.E.I.C., (B.Sc., mech., Manitoba, 1950), on December 15th became engineer officer of "H.M.C.S. St. Laurent" (destroyer escort), Halifax, N.S. His earlier posting was as project officer for naval ships repairs and conversions at Canadian naval headquarters in Ottawa.

G. F. (Bud) Coote, M.E.I.C., (B.Sc., civil, Alberta, 1940), manager of the Accurate Exploration Ltd., Edmonton District, was promoted to general manager, of the firm, at head office, Calgary. The appointment was made in April.

John R. Sutherland, M.E.I.C. (B.Sc., civil, Sask., 1953), has been promoted from project engineer to division engineer, at Rosetown, Sask.

S. K. McWalter, M.E.I.C. (B.E., chem., Sask., 1948), of the British American Oil Company has taken over the post of operating superintendent at the company's Port Moody Refinery, New Westminster, B.C., following service as senior project engineer at head office, Montreal East, Que.

Roger C. Egglestone, M.E.I.C., (B.Sc., petroleum, Alberta, 1955), of the firm of Sun Oil Company, has been transferred from Estevan, Sask., to Calgary. Now engaged in production engineering, he was earlier a field engineer.

Frank Ross, M.E.I.C., (Higher Nat. Cert., elec., Birmingham Central Technical College, 1947), a member of the switchgear and motor control department, Canadian Allis Chalmers Ltd., St. Thomas, Ont., has been promoted to sales engineer on electrical equipment for the Montreal district sales office. Mr. Ross was earlier connected with Bepco Canada Limited, and the Amalgamated Electric Corporation Ltd.

Lt. Col. A. C. Cluff, M.E.I.C., (B.Sc., from the Saskatchewan area, to Army mech., Queen's, 1936), has been posted headquarters, Ottawa, as assistant director of Works, (stores). In the Saskatchewan area he served as area engineer with the rank of major.

D. R. Robson, M.E.I.C., (B.E., mech., Nova Scotia Technical College, 1950), chairman of the Amherst Branch of the E.I.C. in 1955, is a consulting engineer with the firm of N. H. McFetridge and Associates, consulting engineers at Dartmouth, N.S. Mr. Robson has been until the present time, plant superintendent of the No. 2 plant of the firm of Enamal Heating Products Ltd., Amherst.

John J. Rowan, M.E.I.C., (B.Sc., civil, Ecole Polytechnique, 1935; B.Sc., mech., Massachusetts Institute of Technology, 1936), has been promoted from assistant refinery manager to manager of the Montreal East Refinery, Imperial Oil Limited, Montreal. Mr. Rowan was a member of the Sarnia Branch Council of the E.I.C. in 1952 and 1953.

Norman Lapierre, JR.E.I.C., (B.A.Sc., civil, Laval University, 1955), formerly field engineer for the Baie Comeau Company is at present employed as engineer and estimator for C. Jobin Ltee., general contractors in Quebec City. Mr. Lapierre is secretary of the Baie Comeau Branch, E.I.C.

James D. Kingston, JR.E.I.C. (B.Sc. Civil, Queen's, 1954), formerly job superintendant with Temiskaming Construction Limited at Chelmsford, Ont., is a newly appointed project engineer, Hill-Clark-Francis Limited, Kirkland Lake, Ont.

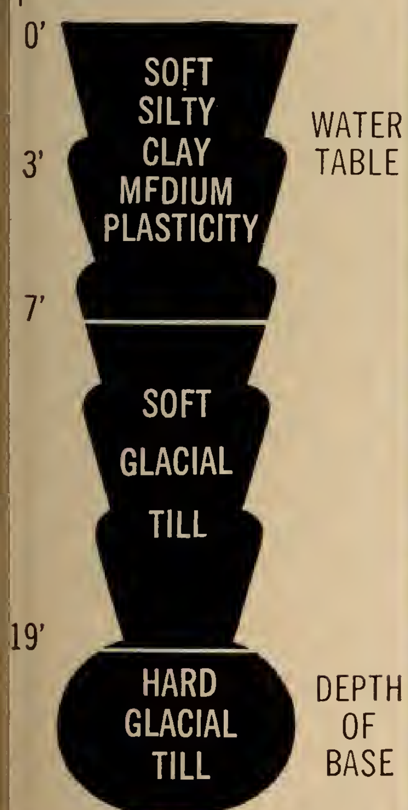
Mattio O. Diorio, JR.E.I.C. (B. Eng., Metall., McGill, 1957), of the Dominion Brake Shoe Company, Joliette, Que., formerly assistant works manager, has been appointed works manager of the Joliette plant. Mr. Diorio joined the company in 1954.

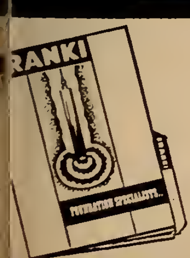
Gordon K. Hunter, JR.E.I.C. (B.Sc., civil, Toronto, 1950), an engineer concerned

RANKI FACTS

LIENT:
Department of Public Works,
Province of Saskatchewan
OCATION:
University of Saskatchewan,
Saskatoon, Saskatchewan
RCHITECT & ENGINEER:
Izumi, Arnott and Sugiyama,
Regina, Sask.
ONTRACTOR:
W. C. Wells Construction Co. Ltd.,
Saskatoon
YPE OF STRUCTURE:
Research Building
UMBER OF CAISSONS:
66 Standard Franki Caisson —
22" diameter
Fully Reinforced
/ORKING LOAD:
100 Tons
EPTH OF CAISSONS:
Average Driven Length — 20'-0"
Average Concreted Length — 15'-7"

YPICAL BORING LOG





iterature-This series of job highlights, as well s other descriptive literature, will be sent o you upon request to Franki of Canada Ltd.,

Franki method offers solution to differential settlement problem

Problem

The Saskatchewan Research Council building is one of four new structures on the University of Soskatchewan Campus, constructed on Franki Caissons.

The site soil conditions posed the problem of the transfer of heavy column loads to a suitable bearing stratum below the excavated grade. High water conditions required the use of a foundation eliminating the difficulties of deep excavation. The overlaying clay was inadequate to carry loads transferred by spread footings. The most significant problem was to determine the depth at which foundations could be based, for although the bearing capacity of soil increased with depth, the elevation at which differential settlements could be held within permissable limits was not obvious.

Solution

The Franki base is made by ramming zero slump concrete into the supporting soil with blows of 140,000 foot pounds of energy. Twenty such blows are required to expel each 5 cubic feet of concrete in the base to obtain 120 Ton bearing capacity. Concrete is added in the base until the required blows are attained.

Thus the engineers were assured that uniform bearing was achieved under each caisson, thereby eliminating the possibility of differential settlement and, at the same time, securing a measure of the bearing capacity of each base.

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QUEBEC OTTAWA TORONTO EDMONTON VANCOUVER

with the improvement of highways and transportation has been awarded an Esso Good Roads Scholarship. Formerly a senior project design engineer with the Ontario Department of Highways, he is now registered in a course in transportation engineering at the Institute of Transportation and Traffic Engineering, University of California.

P. J. Pride, JR.E.I.C., (B.Sc. Metall., Queen's 1956), has joined the Arvida works, Aluminum Company of Canada, technical division and will work as an engineer in the metallurgical development department. With the Aluminum Company since 1956 he was previously a development engineer and metallurgist in the remelt department at the Shawinigan smelter.

K. Linn MacDonald, JR.E.I.C. (B.Sc., mech., Manitoba, 1956), formerly an engineer with the Ontario-Minnesota Pulp & Paper Co., Fort Frances, Ont. has been appointed plant engineer, Canadian Splint and Lumber Corporation Ltd., Pembroke, Ont.

Edward L. Littlejohn, JR.E.I.C. (B.A.Sc., chem., Toronto, 1949), of the Union Carbide organization, Toronto, has been named as assistant to the president of the Visking Company, Division of Union Carbide Canada Limited. Mr. Littlejohn joined the organization in 1949, and has since 1956 been manager of public relations, Union Carbide Canada Limited, at Toronto. He will now be located at the Visking Company office and plant at Lindsay, Ont.

J. McGown, JR.E.I.C., (B.Eng., mech., McGill 1951), formerly road foreman of engines, Kootenay Division, of the Canadian Pacific Railway, Nelson, B.C., has been named master mechanic of the Revelstoke Division, Revelstoke, B.C.

A. W. Saunders, JR.E.I.C. (B.Eng., civil, McGill 1949), flight test engineer, Trans-Canada Air Lines, Dorval Airport, Montreal, has joined the de Havilland Aircraft of Canada Ltd., as a test pilot at Downsview, Ont.

Keith S. Preston, JR.E.I.C., (B.Sc. civ. & mech., New Brunswick, 1955), of the construction and maintenance department, Imperial Oil Ltd., has been appointed assistant resident engineer of construction with Dominion Tar and Chemicals Company Ltd., Hamilton, Ont.

G. B. Weld, JR.E.I.C. (B.E. mech., Nova Scotia Technical College, 1955; M.Eng., mech., Sheffield, 1957), has been appointed assistant professor of mechanical engineering, Nova Scotia Technical College, Halifax. Until his present appointment Mr. Weld was assistant to the director, National Research Council, Halifax, N.S.

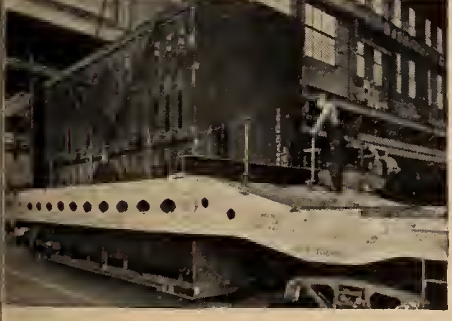
J. R. McMackin, JR.E.I.C. (B.Sc. Civil, New Brunswick, 1949), of Defence Construction (1951) Ltd., has been transferred from North Bay, to Camp Petawawa, Ont. Mr. McMackin has in each area been employed as a project engineer.

Claude Francoeur, JR.E.I.C., (B.A.Sc., civil, Laval 1955), formerly a project engineer on the Lake Ste. Anne reservoir project of the Perini Cartier Construction Company is now on the engineering staff, main office of the firm, Montreal.

Captain J. G. Forth, JR.E.I.C., (R.M.C., 1952; B.A.Sc., chem., Toronto, 1954), formerly officer commanding, First Airborne Troop R.C.E., Calgary, has been posted as second-in-command of 24 Works Company, R.C.E., Camp Borden, Ont. While stationed at Calgary, Captain Forth was responsible for the command, training, and control of the only airborne engineer unit in Canada.

Ross H. Curtis, JR.E.I.C. (B. Eng. elec., McGill, 1950), formerly sales engineer, R.C.A. Victor Company Ltd., Montreal, has been appointed manager, engineering products division, marketing dept., Calgary.

M.E.M. Gibson, JR.E.I.C. (B.A.I., civil, Trinity College, Dublin, 1954), was formerly field soils engineer, H. G. Acres &



• PERSONALS

Co., Labrieville, Que., on the Bersimis No. 2 project. He has recently accepted an appointment as design engineer with R. E. Winter and Associates, at Toronto.

R. E. Chamberlain, JR.E.I.C. (B.A.Sc. elec., University of British Columbia, 1953), of the Bailey Meter Company Limited, Montreal, has been transferred to Quebec City, Que. Mr. Chamberlain has relinquished the work of project engineer to become sales-service engineer in his new location.

Peter Glockner, JR.E.I.C. (B.Eng., civil, McGill 1955; M.Sc., structural Massachusetts Institute of Technology, 1956), has since then been employed as a design engineer for C. C. Parker, Whittaker & Company, consulting engineers of Edmonton, Alta. Early in 1958 he was appointed an assistant professor of applied mechanics, University of Alberta.

Flying Officer W. G. Williams, JR.E.I.C., (B.Sc., civil, Queen's 1955), is a construction engineer officer at the R.C.A.F. Station, Calgary, Alta.

Flying Officer Williams was formerly on the staff of construction engineering branch at Training Command Head quarters, R.C.A.F. Station, Trenton, Ont.

John S. Taylor, JR.E.I.C. (B.Eng., civil, McGill, 1949), who was assistant to general superintendent, reduction division, Arvida Works, Aluminum Company of Canada, is now technical superintendent, Beauharnois Works, of the same company.

Mr. Taylor served on the executive from 1955-56. Prior to his transfer he was vice-chairman of the Saguenay Branch of the E.I.C.

Richard Francis Critchley, JR.E.I.C., (B.Eng. mech., Saskatchewan, 1955), lately of Montreal, as production engineer for Dominion Engineering Company Limited is studying in Great Britain according to the provisions of an Athlone Fellowship. At present he is associated with the firm of Vickers-Armstrong (Engineers) Ltd., at Newcastle-upon-Tyne, Mr. Critchley will do post graduate work in the department of applied mechanics at the University of Sheffield in his second and final year in England.

F. D. Malloch, JR.E.I.C., (B.Sc., mech., Queen's, 1951), has transferred his services from the Department of Northern Affairs and National Resources to the Scarborough, Ont., firm of James Howden and Company of Canada Ltd. He is employed in the heat transfer division of that organization.

E. A. Beaumont, JR.E.I.C., (B.A.Sc., civil, British Columbia, 1949), formerly divisional engineer, location branch and district engineer, is now regional location engineer with Dept. of Highways, Prince George, B.C.

Donald S. Miller, JR.E.I.C., (B.Sc., mech., Queen's 1954), has resigned from the Royal Canadian Air Force to accept an appointment as lecturer, mechanical engineering department at Royal Military College, Kingston, Ont. He is pursuing post graduate studies leading to a masters degree in mechanical engineering. A former sabre pilot, he was stationed in Germany with the 4(f) Wing, R.C.A.F., at Baden - Soellingen, from 1955 to 1958.

J. H. Whelen, JR.E.I.C., (B.Sc., C.E., civil, U.N.B. 1952; S.M.; industrial management, M.I.T., 1954), has transferred his services from the economic planning and market research department of Canadian International Paper Company to Hygrade Containers, Ltd., Toronto division. His post is that of marketing manager.

J. P. Hartt, JR.E.I.C., (B.A.Sc. civil, Toronto, 1950), has accepted an appointment with the department of engineering teaching staff of Essex College, Assumption University of Windsor, Wind-

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Super-Duty, for service temperatures up to 3300°F. Highly resistant to slag and spalling attack. Needs no special prefiring, and can be cold-cast accurately to any size or shape. Resists to a high degree products of combustion, also disintegration in reducing or corrosive atmospheres. High cold strength and ready for service in 24 hrs.

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• PERSONALS

sor, Ont. Mr. Hartt's recent engineering experience was with the St. Lawrence Seaway Authority, civil engineering department at Welland, Ont.

W. B. McLachlan, S.E.I.C. (B.Eng. elec., McGill, 1958, has joined the junior engineer training program of the Ontario Hydro Electric Commission, at Thorold, Ont.

S. W. P. Wyszpkowski, S.E.I.C. (B.A.Sc. chem., Toronto 1958), is employed as a development engineer, for the Du Pont of Canada, textile fibres division, at Kingston, Ont.

C. A. Laferriere, S.E.I.C. (B.A.Sc. civil, Toronto 1957), formerly field engineer in building construction for the firm of Hill-Clark-Francis, Ltd., at Noranda, Que. has been named resident engineer in the field of municipal engineering, for Desjardins and Sauriol, consulting engineers, Pont Viau, Montreal.

Gilles Chartrand, B.A.Sc., chem., Ecole Polytechnique 1957), is employed as a technologist with the Shell Oil Company of Canada, Montreal.

Valmond Robichaud, S.E.I.C., (B.Sc. civil, New Brunswick, 1957), formerly an assistant engineer, Aluminum Company of Canada, at Shipshaw, Que., has been appointed assistant resident engineer, Department of Public Works, Trans-Canada highways division at Dartmouth, N.S.

J. S. Luffman, S.E.I.C. (B.Sc., civil, New Brunswick), is in charge of "Butler Buildings" for Fry's Engineering Co. Ltd., St. John's, Nfld.

Flying Officer R. H. Jones, S.E.I.C., (B.E. civil, Nova Scotia Technical College, 1958), is assistant construction engineering officer at the R.C.A.F. station, Clinton, Ont.

E. J. Jackiw, S.E.I.C., (B.S., mech., Queen's 1958), is now junior engineer at Horton Steel Works, Fort Erie, Ont.

Lieutenant F. J. Bradbrook, S.E.I.C., (B.E., civil, Nova Scotia Technical College, 1958), has been following the young officers training course with R.C.S.M.E., at Camp Chilliwack, B.C. since his graduation. He is presently posted at Camp Petawawa, Ont. where he is a headquarters lieutenant with 1 Field Squadron, R.C.E.

Norman Benoit, S.E.I.C. (B. Eng., elect., McGill 1958), is following a two-year training course with Canadian General Electric Company Ltd., Peterborough.

E. J. Stewart, S.E.I.C., (B.E., elec., Nova Scotia Technical College 1958), is an assistant engineer with the Canadian Pacific Railway, Montreal, communications department.

B. W. Sarjeant, S.E.I.C., (B.Sc. eng. civ. London, 1958), is design engineer with the firm of Read, Jones, Christoffersen, consultant engineers at Vancouver, B.C.

Kenneth E. Tingley, S.E.I.C., (B.Eng. elect., Nova Scotia Technical College, 1957), has left the Canadian General Electric Company Ltd., Peterborough, Ont., to work with the Linde Air Products, division of Union Carbide Canada. He has been assigned to the development laboratory at Newark, N.J. for a one or two year training period.

Murray E. Markanen, S.E.I.C., (B.Eng. civil, McGill, 1957), has left the firm of C. A. Pitts, General Contractor Ltd., seaway contractors at Cornwall, Ont., Mr. Markanen has joined a Brockville, Ont. company, Permanent Transit-Mix Concrete Ltd.

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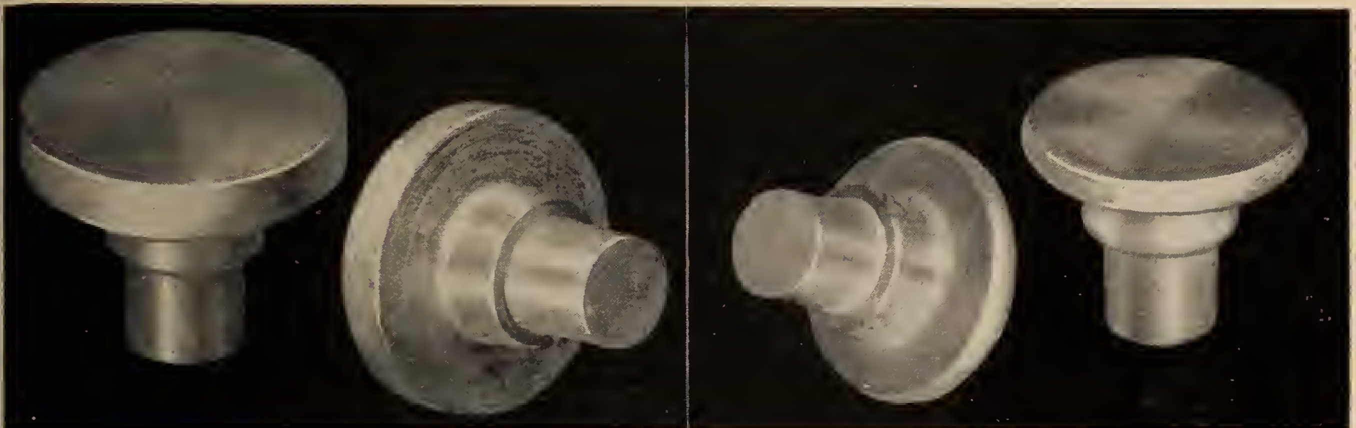
Standardize your Specials

THROUGH STELCO COLD HEADING



Machined "Special" . . . slightly redesigned as a Cold Headed "Standard"

The simple Flat Head Shoulder Rivet shown on the left above (enlarged), was slightly amended as seen on the right, to permit production by cold heading instead of by machining. The elimination of scrap loss, combined with increased speed of production, brought a saving of 80% to the purchaser.

Pictured below are several other "specials" standardized by Stelco with considerable cost reduction.

57121.B

Result - 80% Savings!

Stelco's modern bolt-making facilities, plus the services of Specialty Fastener Representatives, offer you three ways to save on "special" fasteners —

FIRST — Many types of contoured parts can be produced by cold heading more economically than by machining. Not all savings are as impressive as the one illustrated above, but *cost reductions in the region of 40% are not uncommon* and are often accompanied by minor redesigning which adds to the strength of the part. Secondary operations, such as thread rolling or cutting, knurling, extruding, flattening, piercing, drilling, broaching, and bending are also provided for in Stelco's facilities.

SECOND — Stelco will carry as stock items your long-run repetitive "specials" — giving you a ready source of supply and the benefit of large-quantity prices.

THIRD — Your "special" requirement might already be in stock as a Stelco "Standard" — or possibly an existing "special" could meet your needs. In either case you would realise a saving.

Why not ask Stelco's Engineers to examine *your* "specials"? If they are adaptable to production by the cold heading process your cost reductions will be substantial. Any Stelco Sales Office is at your service.

THE STEEL COMPANY OF CANADA, LIMITED

Executive Offices: Hamilton and Montreal

Sales Offices: Halifax, Saint John, Montreal, Ottawa, Toronto, Hamilton, London, Windsor, Winnipeg, Edmonton, Vancouver. J. C. Pratt & Co. Limited, St. John's, Newfoundland.

NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute and abstracts of the papers presented at their meetings

BORDER CITIES

A. W. Malmberg, JR.E.I.C.,
Branch News Correspondent

ON OCTOBER 17, 1958, 160 members and guests of the Border Cities Branch of the E.I.C. honoured Dr. K. F. Tupper, O.B.E., president of the E.I.C. with a dinner and dance at the Essex Golf Club.

Dr. Tupper who had just returned from a visit to the U.S.S.R., spoke to the gathering on observations and impressions formed on his trip, which were both interesting and enlightening.

FREDERICTON

Lyle W. Smith, JR.E.I.C.,
Branch News Correspondent

AT A BRANCH MEETING on November 17, 1958 Mr. Cunningham of New Brunswick Telephone Company traced the development of transister tubes and their application in the telephone industry. He related some of the expected developments in the telephone industry and explained how they would be of service to the public. He also mentioned use of microwave networks and picture tube installations in telephone network.

SIR CLAUDE GIBB was the speaker at the meeting of October 28. Sir Claude is president of C. A. Parsons Co. Ltd., England, and his subject was "The Development of Nuclear and Orthodox Power Stations."

HAMILTON

W. A. H. Filer, JR.E.I.C., *Sec.-Treas.*
J. R. Currie, M.E.I.C.,
Branch News Reporter

AT THE NOVEMBER MEETING of the Hamilton Branch, on November 13, there was a panel discussion on the "Die Casting Process". The speakers were five representatives from four of the major Canadian producers of die castings. The panel chairman was N. J. Clark of Barber Die Casting Ltd. The other members were S. Bulmer, W. H. Weatherhead, and R. D. MacLean, all of the Die Caster's Section of the Automotive Parts Manufacturers Association. Mr. Clark gave a brief history of die casting in Canada, and the panel answered questions from the floor.

A technical session was held, followed by an informative film entitled "The Shortest Way".

The Hamilton Branch held its Annual Social Evening on November 28.

Members and guests were welcomed by Branch Chairman R. C. Mitchell, and L. C. Sentence introduced Dr. K. F. Tupper, president of the Institute. Dr. Tupper spoke briefly about activities of the E.I.C. in the international realm. He also gave a most interesting and informative talk about the recent trip to Russia made by Dr. Tupper and Dr. Page.

This event also marked the first official visit to Hamilton of Dr. Garnet Page in his new position as general secretary.

Earlier in the day Dr. Tupper and Dr. Page were taken on a tour of the nuclear research development at Mcmaster University by Dr. Hodgins and Dr. Thode, and on Friday afternoon the guests met with the Hamilton Branch Executive.

CORNER BROOK

E. R. Skanes, JR.E.I.C., *Sec.-Treas.*
H. A. Hinton, JR.E.I.C.,
Branch News Reporter

PROFESSOR D. L. MORDELL, dean of engineering, McGill University, spoke to the Corner Brook Branch, E.I.C. at their November 5 meeting. Subject of the address was space travel which, he said, is here now, insofar as it is technically possible within the limitations of our present knowledge. The recent American moon-rocket, although it went only about one-third the intended distance, was actually a very near miss. Many complicated problems remain to be overcome before manned space ships will be possible, but judging from the time taken for means of land, sea, and air travel to reach their present high state of development from the first steam carriage, a manned flight to the moon may be expected within ten years. Greatest need of this field, he said, is for men with better all-round education, not merely well-trained technicians. The problems that will be brought by the age of space travel now opening, will require independent creative thinking on the part of engineers, administrators, politicians, and men in many other fields.

KINGSTON

D. I. Ourom, JR.E.I.C.
Secretary and Branch News Reporter

MODERN INSTRUMENTATION in Control of Chemical Processes," was discussed by G. B. Hall, instrument engineer, Canadian Industries Limited, Montreal, at a meeting of November 4, 1958.

Mr. Hall outlined the uses and advantages of the various types of instruments available for the control of chemical processes. The discussion centred around the instrumentation required to control the operation of an ammonia plant. The limitations of materials were reviewed. and the desirability of duplicating key pieces of control equipment was discussed. The use and operation of the various pneumatic and electronic controller-recorders was described. The talk closed with a discussion of the application of automatic controls to processes.

MONTREAL

Dr. K. L. Pinder, JR.E.I.C.
Branch News Correspondent

THE NATIONAL FILM BOARD, Montreal, entertained members of the Montreal Branch on November 12.

The members were introduced to the functions and the background of the Film Board. The range of film types and the awards won by the Board were mentioned. The visitors (200 strong) were conducted through the different laboratories and recording studios.

NEWFOUNDLAND

R. L. Smyth, JR.E.I.C., *Sec.-Treas.*
R. P. Hunt, JR.E.I.C.,
Branch News Reporter

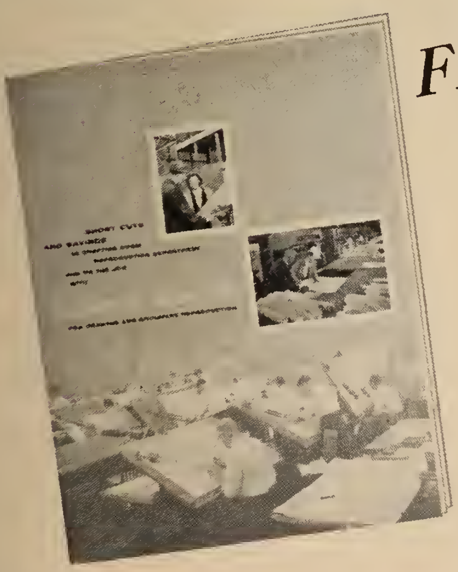
DEAN D. L. MORDELL, dean of engineering, McGill University, Montreal, was guest speaker before the Newfoundland Branch on November 2, 1958. In his talk, "An Engineer Looks at Space Travel". This lecture is reported elsewhere on this page.

SARNIA

R. F. Routledge, M.E.I.C., *Sec.-Treas.*
C. M. Stewart, JR.E.I.C.,
Publicity Chairman

PROFESSIONAL MANAGEMENT TODAY was the subject aired at a joint meeting with the Sarnia Branch of the Chemical Institute of Canada.

George E. Terris, vice-president of Payne Ross Ltd. of Montreal and Toronto, management consultants, was the speaker.



The meeting was under the chairmanship of J. H. Douglas. The speaker was introduced by M. Waghorne and thanked by N. Shipley.

TORONTO BRANCH

G. F. R. Norton, JR.E.I.C.
Branch News Reporter

D. S. Moyer, M.E.I.C., *Sec.-Treas.*

AN URBAN PLANNING CONSULTANT addressed the October 30 meeting of the Branch in a talk on "The Satellite City".

Mr. R. S. Dennison of Bromalea Consolidated Developments Ltd., dealt with the advent of the satellite city concept to fulfill human needs in areas of extensive urban development such as Metropolitan Toronto.

This was a joint meeting with the joint area committee. R. H. Self chaired the meeting. B. Hardcastle introduced the speaker and W. Sefton thanked the speaker.

Some guests at the Fifth Annual Engineers' Ball, Niagara Falls. 1958. In this group: D. A. Barnum, T. C. Keefer, A. W. F. McQueen. J. A. McLaren. C. T. Carson, B. H. Goodings, T. M. Medland, A.P.E.O., J. K. Picken, Mrs. Barnum, Mrs. Keefer, Mrs. McQueen, Mrs. Carson, Mrs. Picken, Mrs. Goodings.

At left, visit of F. S. Snow, C.B.E., past president of the Institution of Structural Engineers, London, to the Toronto Branch. From left to right: M. S. Yolles. W. P. Dumbleton. W. Sefton, J. L. Kellerman, T. Howarth, Mr. Snow, L. H. Fitzwilliam. A. Shuper. Professor A. Davidson, B. Hardcastle, and J. A. McLaren.

• BRANCH NEWS

NOVA SCOTIA TECHNICAL COLLEGE

John Jay, S.E.I.C., *Correspondent*

PROF. MAX BAKER was a special guest at the regular monthly meeting of the executive of the Student Society. He was presented with a small gold penknife by John Jay, the student representative for the Engineering Institute of Canada. It was on the occasion of Prof. Baker's retirement as Faculty Advisor to the group and of Prof. Steeves' succession in this capacity.

PETERBOROUGH

G. M. Locke, JR.E.I.C., *Sec.-Treas.*

J. G. Hooper, M.E.I.C.,
Branch News Reporter

UNDERGROUND COAL MINING, its methods and problems were explained to members of the Peterborough Branch at a November 12 meeting, addressed by William H. Bowes. A stress analyst for the Civilian Atomic Power Department, Canadian General Electric Company, Peterborough, Mr. Bowes was concerned with an issue of current interest, "Men, coal and 'Bumps' at Springhill, N.S."

Mr. Bowes was introduced by John Pawliw and after a question and discussion period was thanked by C. W. Holman.

SAULT STE. MARIE

R. L. Wimperis, JR.E.I.C.,
Sec.-Treas. and Branch News Reporter

PROFESSIONAL RECOGNITION AND STATUS for engineers comparable with that enjoyed by other professions was discussed by Dr. K. F. Tupper, president, E.I.C., in an address to the Sault Ste. Marie Branch on November 11.

Introduced by W. Hogg, Dr. Tupper was thanked by L. F. Mason-Tulby.

While the members dined and listened to Dr. Tupper's address, the ladies dined separately with Mrs. Tupper, and later enjoyed card games. Following the president's address all joined in for the conclusion of the evening.

VANCOUVER ISLAND

J. A. Cowlin, JR.E.I.C., *Sec.-Treas.*

H. F. Coupe, M.E.I.C.,
Branch News Reporter

THE ANNUAL "LADIES NIGHT" was held at the Pacific Club, Victoria, on November 19. Cocktails and dinner followed by an address by Dr. G. C. Carl, director of the Provincial Museum, were enjoyed by members and their ladies.

Introduced by D. Watts, his subject "Island Explorations" covered field work carried out by the Museum staff on the west coast islands of British Columbia. The talk was illustrated with an excellent and very educational colour film entitled "The Sea".

VANCOUVER

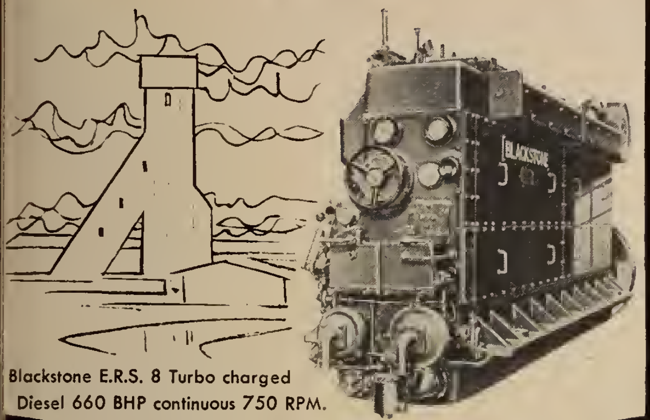
J. J. Kaller, M.E.I.C.,
Branch News Reporter

Ronald Clough, M.E.I.C., *Secretary*

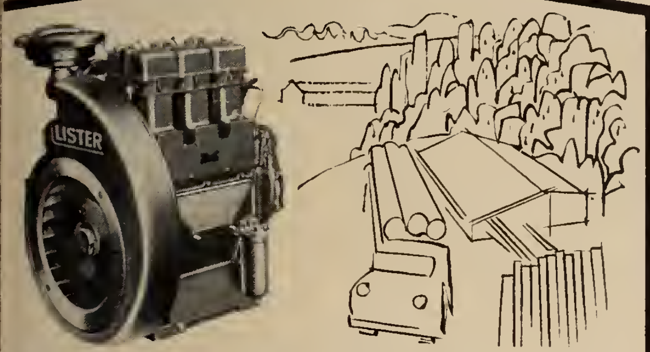
"SMALL BOATS" was the name given a lecture which introduced a variety of boats to assembled Branch members at a meeting held October 29. The authority was Vancouverite John Brandlmayr, consulting engineer, naval architect, and a senior partner of Spencer Boats Ltd.

On November 1 a field trip to "Spencer Boats Ltd." allowed numerous E.I.C. members to have a close look at the production of motorboats and sailboats designed by Mr. Brandlmayr.

On October 21 the Structural Section of the Vancouver Branch arranged a panel discussion on an always timely subject: "The Architect and the Structural Engineer-Relations of Scope of Work." The lively discussion between the panel members and the audience proved that while relations betwen the two professions are very satisfactory the ideas about the scope of work are not quite unanimous. The architects point of view was presented by Messrs. W. Leithead, P. Thornton and K. Gardner,—Messrs. B. Barrett, J. Read and A. C. Smith presented the structural engineer's case. Mr. W. E. Stone was the moderator.



Blackstone E.R.S. 8 Turbo charged Diesel 660 BHP continuous 750 RPM.



Lister HA3 air cooled lightweight Diesel 30 BHP continuous 1800 RPM.

News of Other Societies

Calendar

American Inst. of Chemical Engineers

National meeting, Atlantic City, N.J., March 16-20, 1959.

National Association of Corrosion Engineers

15th annual conference, Chicago, March 16-20, 1959.

American Chemical Society

135th meeting, Boston, Mass., April 5-10, 1959.

American Inst. of Mining, Metallurgical, and Petroleum Engineers

National open hearth steel furnace, coke oven and raw materials conference, St. Louis, Mo., April 6-8, 1959.

International symposium on the physical chemistry of processed metallurgy, Pittsburgh, Pa., April 27-30, 1959.

American Society of Tool Engineers

27th annual meeting, Milwaukee, Wis., April 18-22, 1959.

National Research Council, Canada

Muskeg research conference 5th annual meeting, Winnipeg, Man., March 4, 1959.

Institute of Radio Engineers

National convention, New York, March 23-26, 1959.

Western joint computer conference (jointly with A.I.E.E.), San Francisco, March 2-6; Los Angeles, May 1959.

Joint conference on automatic techniques (jointly with A.I.E.E. and A.S.M.E.), Chicago, May 11-13, 1959.

American Society of Mechanical Engineers

Instruments and regulators division, Cleveland, Ohio, March 29 to April 2.

Gas turbine power conference and exhibit, Cincinnati, Ohio, March 8-11, 1959.

Aviation conference, Los Angeles, March 8-12.

Hydraulics conference, Ann Arbor, Mich., April 13-15, 1959.

Oil and gas power conference and exhibit, Houston, Texas April 19-23, 1959.

Management Engineering Conference (jointly with the Society for the Advancement of Management), New York, April 23-24, 1959.

Metals engineering conference, Albany, N.Y., April 29 to May 3, 1959.

Maintenance and plant engineering conference, Chicago, May 4-5, 1959.

Joint conference on automatic techniques (jointly with I.R.E. and A.I.E.E.), Chicago, May 11-13, 1959.

Design engineering conference, Philadelphia, May 25-28, 1959.

Semi-annual meeting, St. Louis, Mo., June 14-18, 1959.

Applied Mechanics Conference, Blacksburg, Va., June 18-20, 1959.

American Welding Society

Spring meeting and welding show, Chicago, Ill., April 6-10, 1959.

International Union for the Study of Electrothermics

Fourth international congress, Stresa, Italy, May 1959.

Building Research Institute

Eighth annual meeting, Pittsburgh, April 6-8, 1959.

The Society of Naval Architects and Marine Engineers

The society is receiving nominations for the four scholarships for graduate study which it has been offering each year.

The applications should be filed with the Secretary of the Society at 74 Trinity Place, New York, 6, before February 1, 1959.

Canadian Electrical Association

Eastern Zone Meetings, Quebec, Que. January 26-29, 1959.

R. C. E. M. E. Corps Association

The annual general meeting and annual dinner of the R.C.E.M.E. Corps Association was held at the R.C.E.M.E. School at Barriefield, Ontario, on Saturday, October 25, 1958.

Col. R. A. Campbell, OBE Director, Corps of Electrical and Mechanical Engineers, spoke to the meeting.

The following officers were elected as the 1958-1959 executive of the Association: president, Lt.-Col. E. D. Gray-Donald, M.E.I.C., Montreal; first vice-president, Major D. C. Ferguson, Toronto; Hon. Sec.-Treasurer, Lt.-Col. LeSueur Brodie, ED, Toronto. The immediate past president is Lt.-Col. J. K. Bradford, OBE, Toronto.

The annual dinner was attended by approximately 150 members including the following guests:—Gen. the Honourable A. G. L. McNaughton, P.C., C.H., C.B., C.M.G., Hon. M.E.I.C.; Brig. F. J. Fleury, C.B.E., E.D., Vice Q.M.G.; Major C. K. Johnston; Major W. Horan, C.D.; The Pay Corps Association; The Royal Canadian Engineers Association.

The guest speaker was I. N. MacKay, manager of engineering, Civilian Atomic Power Department, Canadian General Electric Company, Peterborough.

At the annual meeting of the R.C.E.M.E. Corps Association: left to right, Lt. Col. J. K. Bradford, past president, I. N. MacKay, guest speaker, Lt. Col. E. D. Gray-Donald, president, Gen. The Hon. A. G. L. McNaughton, and Lt. Col. A. G. Edward.

LIBRARY NOTES

ADDITIONS TO THE INSTITUTE LIBRARY • REVIEWS • BOOK NOTES • STANDARDS

BOOK 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.

*HEAT EXCHANGERS: APPLICATIONS TO GAS TURBINES

Emphasizes design of heat transfer units in connection with gas turbines, so as to obtain an economical unit for various applications. The design of recuperative heat exchangers, regenerators, and air preheaters is presented along with related aspects as test arrangements, stresses and materials, cost, and the question of weight in aircraft units. (W. Hryniszak. Toronto, Butterworth, 1958. 343p., $10.00.)

*THE IMPACT OF HIGH TEMPERATURE TECHNOLOGY

Studies the present status of high temperature technology, and attempts to indicate possible future developments. Areas covered are nuclear power, propulsion, component equipment, aircraft and missiles, electronics, temperature measurements, high temperature process developments, and materials. A report written by graduate students under the guidance of the Harvard Business School Faculty. (V. P. Kovicik and others. Cleveland Heights, High Temperature Associates, 1958. 272p., paper $8.00.)

*BUILDINGS FOR RESEARCH

Discusses the requirements of good laboratory design and provides information on such factors as safety measures, waste removal, corrosion prevention, vents and chains, and modular units. This is followed by descriptions of research buildings in the fields of nucleonics, biology, electronics, and chemistry. A special section deals with atomic processes and equipment as they affect the design of the laboratory. A collection of articles published in Architectural Record since 1950. (New York, Dodge, 1958. 224p., $9.50.)

*ELECTRIC MACHINERY

A coordinated presentation covering transformers as well as both direct and alternating machines. Topics covered are types of windings, voltage relations, magnetic-field relations, energy losses, energy flow, efficiency, ratings, and basic torque relations. These principles are then applied to a detailed analysis of the performance of different types of machines. (C. C. Carr. New York, Wiley, 1958. 537p., $9.25.)

*BIOLOGICAL TREATMENT OF SEWAGE AND INDUSTRIAL WASTES VOL. II: ANAEROBIC DIGESTION AND SOLIDS-LIQUID SEPARATION

Papers dealing with current practices in the field of waste treatment. Part one is concerned with anaerobic digestion while part two discusses the separation of solids from waste water by sedimentation and flotation. Part three discusses elutriation, chemical conditioning, and vacuum filtration. The volume is made up of papers presented at the Conference on Anaerobic Digestion and Solids Handling, New York 1957. (Ed. by J. McCabe and W. W. Eckenfelder, Jr. New York, Reinhold, 1958. 330p., $11.50.)

*A HISTORY OF TECHNOLOGY VOL. IV: THE INDUSTRIAL REVOLUTION

A detailed account of the rise of modern industrialism. Six aspects are discussed: primary production; forms of energy; manufacture; static engineering; communications; scientific basis of technology. The volume is superbly printed and illustrated. (Ed. by Charles Singer and others. Toronto, Oxford University Press, 1958. 728p., $25.00.)

ELEMENTARY STATISTICAL PHYSICS

A fundamental treatment of statistical mechanics, intended for physics students, and also including stochastic processes and transport theory. The Gibbs method of ensembles is used, and the various applications of statistical physics covered are kinetic methods, the principles of detailed balance, the Boltzmann transport equation, thermal noise, and thermodynamics of irreversible processes and fluctuations. Negative temperature, magnetic energy, density matrix methods and the Kramers-Kronig causality relations are also included. Problems and worked examples are used to illustrate the text. (C. Kittel. New York, Wiley, 1958. 228p., $8.00.)

THEORY OF ELECTRICAL MACHINES

A text for final year electrical engineering students, treating the subject in a fairly general manner. The topics covered include electromotive force, windings, effects of load current in armature windings, transformers, synchronous machines, induction machines, a.c. commutator machines and d.c. machines. Purely design problems have not been discussed, but design fundamentals are covered in an appendix. (W. S. Wood. Toronto, Butterworth, 1958. 317p., $10.00.)

STORIES OF MEN AND MACHINES

A beautifully produced picture story of Czech industry published for the 1958 Brussels Exhibition. The photographs are excellent, and the accompanying text contains some charming anecdotes in English, by Ludvik Askenazy and other authors. (Prague, SNTL, 1958.)

*THE PRINCIPLES AND PRACTICE OF SURVEYING, VOLUME 1: ELEMENTARY SURVEYING, 9TH ED.

Various revisions have been made throughout this new edition including sources of maps and surveying information; European-type transits and levels; stadia theory; astronomical data and illustrative problems; circular curves; mine surveying; aerial surveying and photogrammetry. (C. B. Breed and G. L. Hosmer. New York, Wiley, 1958. 717p., $6.50.)

ENGINEERING SYSTEMS ANALYSIS

Intended as a text for undergraduates, the purpose of this volume is to show

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these Notes are now available in the Library. Members of the Institute may borrow books, periodicals, pamphlets, etc. from the Library. The loan period is two weeks, excluding time in transit, and two items may be borrowed at one time. Library hours are: Monday to Friday: 9 a.m.—5 p.m.; Saturday: 9 a.m.—12 noon.

Because of a recent change in policy, publications (except periodicals published by other engineering societies) may no longer be purchased through the Library. If members have difficulty obtaining material locally, it is suggested they write to the Library, and the enquiry will be forwarded to an appropriate bookseller. For further information write to the Librarian.

that methods and techniques of analysis used in one branch of engineering may actually be generalized methods which can be used to solve problems in any field of engineering.

The author commences with a definition and interpretation of engineering analogies. Other chapters cover mechanical vibrations; oscillations in electrical networks; dynamical systems and their characteristics; methods of solution for analogous systems and mixed systems; dimensional analysis and applications; principles of feedback and control; analog and digital computing machines.

Problems and references for further reading are also included. (R. L. Sutherland. Reading, Addison-Wesley, 1958. 223p., $7.50.)

*CREATIVENESS FOR ENGINEERS

Consists of two parts, the first of which discusses a philosophy to stimulate creativeness and to motivate the potentially creative person. The second part deals with a creative approach aimed at producing more effective reaction between the individual and his effort. Appendices provide means for practical application of these principles. A second edition of this book is now available. (D. S. Pearson. University Park, Pa., Pennsylvania State University, The Author, 1958. 122p., $3.75.)

SCIENCE STUDENTS' GUIDE TO THE GERMAN LANGUAGE

A grammar book for the use of science students studying German, based on the author's own teaching methods. Particular attention has been paid to special difficulties such as sentence structure and the participial phrase. The examples in the grammar and the passages for reading are taken from scientific writings, mainly in the fields of chemistry and physics, although passages from other fields are included. In addition to the basic grammar, the book contains many pointers useful for those learning to read German scientific texts. (A. F. Cunningham. Toronto, Oxford University Press, 1958. 186p., $2.00.)

THE PRINCIPLES OF SCIENCE

William Stanley Jevons played an important role in the development of modern symbolic logic. He pioneered in the construction of calculating machines, actually building a workable machine for the solving of logical problems; he used statistical data for studying economic trends; and initiated a new period in English economic theory with his contributions to the mathematical theory of economic utility, all this before his death in 1882. This is a reprint of the second edition of his book, his chief work on logic, and is a classic of logic and the scientific method. His logic is a simplification and correction of that of Boole. (W. S. Jevons. N.Y., Dover, 1958, 786p., $2.98.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Atomic energy

Britain uses atoms, London, Central Office of Information, 1958.

Selected readings on atomic energy. Washington, U.S. Atomic Energy Commission, 1958. 25 cents.

Canada. Minerals

Canada; map of principal mineral areas. Canada, Dept. of Mines and Technical Surveys, 1958. (Mines resources division and geological survey of Canada). 25 cents.

Iron ore and other raw-material sources for a primary iron and steel industry in Western Canada, by T. H. Janes. Canada, Dept. of Mines and Technical Surveys, Mineral resources division, 1958. (Mineral information bulletin MR 28). 25 cents.

Milling plants in Canada; metallic ores. Canada, Dept. of Mines and Technical Surveys, Mineral Resources Division, 1958.

City planning

Human considerations in urban development. Ottawa, Central Mortgage and Housing, 1958.

Concrete testing

Danish National Institute of Building Research, Committee on alkali reactions in concrete. Progress report: M 1: Preparation of samples for microscopic investigation, by Ervin Poulsen.

• LIBRARY NOTES

Electrical engineering

Symposium on the provision of adequate electrical installations in buildings. London, Institution of Electrical Engineers, 1958.

Electrical Research Association: Technical reports: F/T 187 — The calculation of continuous current ratings and rating factors for transmission and distribution cables, by H. Goldenberg. L/T360 — The polymerization of organic compounds by ionizing radiation, by C. E. King. L/T 364 —The effects of small discharges on some insulating materials. II at atmospheric and reduced pressures, by N. Parkman. N/T 77—An investigation into the causes of excessive iron losses in electrical machines, by D. A. Jones. N/T 78—An electrical analogue of magnetic domains, by P. F. Davis. V/T 132—Data required for the solution of power system problems.

Fuel

Fuel and power industries in the United Kingdom. London, U.K.I.S., 1958.

Great Britain

Britain; an official handbook. London, Central Office of Information, 1958.

Illuminating engineering

Recommended levels of illumination. (Reprinted from Illuminating Engineering, Aug., 1958.)

Industrial relations

Manpower problems in economic development; a selected bibliography, prepared by K. Simpson and H. C. Benjamin. Princeton, Princeton University, Industrial Relations Section, 1958. $2.00.

Permafrost

A subsurface organic layer associated with permafrost in the Western Arctic, by J. R. Mackay. Canada, Dept. of Mines and Technical Surveys, Geographical Branch, 1958. (Geographical paper no. 18) 50 cents.

Radio engineering

Selected abstracts from the Journal of the British Institution of Radio Engineers, 1946-1958. London, The Institution. 1958. 3s. 6d.

St. Lawrence River

Gulf of St. Lawrence ice survey, winter 1958, by W. A. Black. Canada, Dept. of Mines and Technical Surveys, Geographical Branch, 1958. (Geographical paper no. 19) 75 cents.

Improved winter navigation in the lower St. Lawrence River and Gulf region, presented by The Lower St. Lawrence and Gulf Development Association and prepared by H. Massue. Montreal, 1958.

UNESCO

Inaugural handbook of The Canadian National Commission for UNESCO. Ottawa, 1958.

V-Belts

Dodge V-Belt drives. Toronto, United Steel Corporation Ltd., Dodge Manufacturing Division, 1958.

STANDARDS RECEIVED

Canadian standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2.

B53-1958: Code for identification of piping systems, 2d ed. 75 cents.

C 22.2 No. 31-1958: Construction and test of switchgear assemblies. $1.00.

C22.3 No. 4-1958: Electrochemical corrosion of underground metallic structures. $1.50.

Canadian Underwriters' Association standards. Canadian Underwriters' Association, 480 St. John St., Montreal.
No. 58: Standard for the storage and handling of liquefied petroleum gases.

THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: K. F. Tupper, M.E.I.C. Treasurer: T. W. Eadie, M.E.I.C. General Secretary: Garnet T. Page, M.E.I.C

FEBRUARY 1959

vol. 42 no. 2

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

MEMBERSHIP

Indexed in The Engineering Index

(20,450 copies of this issue printed)

MEET THE AUTHORS

J. A. Thomas, M.E.I.C., Chief Engineer, civil division, The Shawinigan Engineering Company Limited, Montreal. *(Engineering Features of the Beechwood Development).*

Mr. Thomas graduated with a B.A. and a B.Sc. degree in 1936 and 1942 respectively, from Queen's University, Kingston, Ont.

He joined the Shawinigan Engineering Company in 1948 as hydraulic engineer, having had previous experience in the design of hydro-electric projects. In 1956 he was appointed chief engineer, civil division.

He is a member of the American Society of Mechanical Engineers, the Canadian Standards Association and the International Electro-Technical Commission.

R. E. Grout, M.E.I.C., Chief Engineer, electrical division, The Shawinigan Engineering Company Limited, Montreal. *(Engineering Features of the Beechwood Development).*

Mr. Grout received his engineering education at the University of Alberta (B.Sc., electrical, 1936).

He joined the Shawinigan Engineering Company in 1937 and has been engaged on the design of large hydro-electric generating stations and major transformer and switching stations. He was appointed chief engineer, electrical division in 1956.

He is a member of the American Institute of Electrical Engineers, and the Canadian Electrical Association.

W. S. McIlquham, M.E.I.C., Hydraulic Engineer, Dominion Engineering Works Limited, Lachine, Que. *(Beechwood Kaplan Turbines—Hydraulic and Mechanical Features).*

Mr. McIlquham holds an engineering degree from Queen's University (B.Sc., civil, 1923). After eighteen months of experience with the Bell Telephone Company of Canada, he joined Dominion Engineering Works Ltd., as hydraulics and design engineer. From 1942 to 1946 he served the Canadian army R.C.O.C. and R.C.E.M.E., and retired as a major.

Upon his release from the army he returned to the hydraulic department of Dominion Engineering Works.

L. M. Boyd, M.E.I.C., Chief Engineer, hydraulic division, Dominion Engineering Works Limited, Lachine, Que. *(Beechwood Kaplan Turbines—Hydraulic and Mechanical Features).*

Mr. Boyd graduated from Queen's University with a B.Sc. degree in mechanical engineering in 1934, and immediately joined the hydraulic division of Dominion Engineering Works Ltd., as design engineer. In 1940 he was transferred to the Longueuil division of the company as production engineer, responsible for the naval gun-mount production. In 1945 he returned to the head-office to organize a company-wide program of standardization. He was transferred back to the hydraulic division in 1947 as mechanical and production engineer. In 1952 he was appointed to his present position.

K. D. Sheldrick, Sales Manager, district operations, Bailey Meter Co. Ltd., Montreal. *(Methods and Trends in Automatic Combustion Control).*

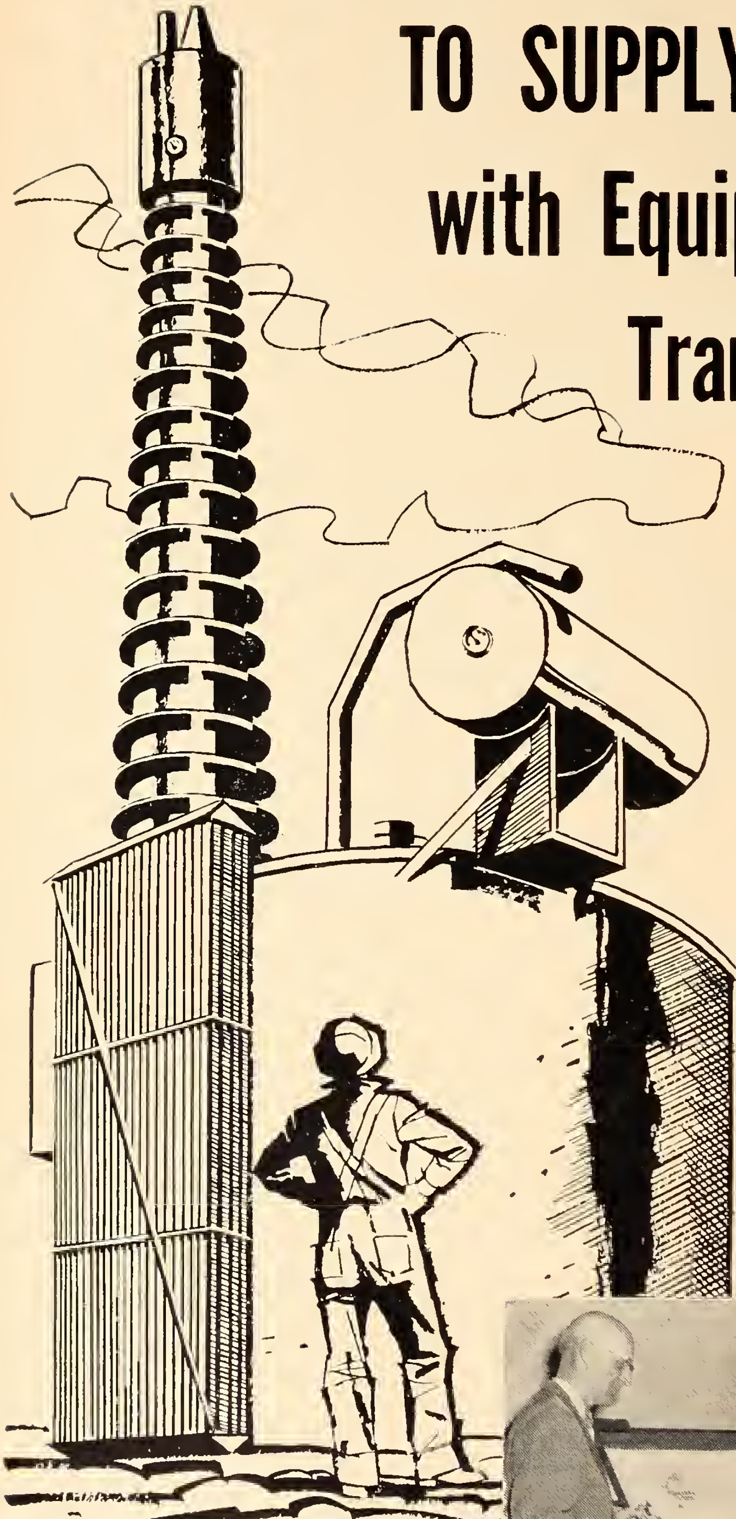
Mr. Sheldrick graduated in arts from the University of New Brunswick in 1927. After two years with the Nashwaak Pulp and Paper Co. Ltd., he attended an industrial course in instrumentation and combustion engineering for a one year period. From 1930 to 1941 he was engaged in sales and service engineering with the Bailey Meter Co. Ltd. in eastern Canada. In 1942 he joined the Canadian Army R.C.E.M.E., retiring with the rank of lieutenant colonel, commanding officer of the 3rd Technical Regiment, R.C.E.-M.E. (Militia) in 1946. He returned to the Bailey Meter Co., and held the post of manager for the firm's Montreal district office from 1947 to 1957. In 1958 he was promoted to his present position. He is a member of the Council of the R.C.E.M.E. Corps Association and chairman of the Corps History Committee.

J. R. Houghton, M.E.I.C., Assistant Works Manager, communications equipment division, Northern Electric Company Limited, Montreal. *(The Role of the Technical Assistant in Industry).*

Mr. Houghton is an engineering graduate from McGill University (B.Eng., mechanical, 1937). Upon graduation he joined Northern Electric Co. Ltd. as a telephone engineer. He subsequently occupied various supervisory positions leading to his appointment in 1951 as superintendent of manufacturing engineering in the communications equipment division. He was named engineer of manufacture in 1956. He is on the Board of Examiners of the C.P.E.Q., and chairman of the Professional Technicians' Committee of the C.P.E.Q. He is also a member of the Canadian Standards Association and the Institute of Administration.

We are indebted to the following for their contributions to the article *Fifty Years in Aeronautical Engineering:* H. C. Luttman, Secretary, Canadian Aeronautical Institute; R. D. Richmond, M.E.I.C., Chief Engineer, Special Weapons, Canadair Limited; F. R. Thurston, Acting Director, National Aeronautical Establishment; F. H. Keast, Chief Engineer, Orenda Engines Ltd.; Air Vice Marshal M. M. Hendrick, Chairman, Canadian Joint Staff, Washington; R. B. McIntyre, Assistant Engineering Director, De Havilland Aircraft of Canada Ltd.; W. H. Riggs, Vice-President, Manufacturing, Avro Aircraft Ltd.

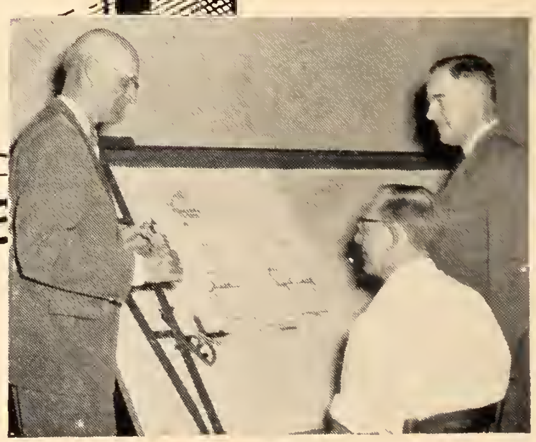
CANADIAN GENERAL ELECTRIC TO SUPPLY ONTARIO HYDRO with Equipment for E.H.V. Transmission Tests



Extra High Voltage power transmission over long distance is relatively new and possesses many unknown facets. To investigate fully its possibilities and thus provide economical transmission of power from remote generating stations, Ontario Hydro has initiated EHV Project Coldwater. The Coldwater Ontario Research Station, now in the planning stage, will uncover such characteristics of EHV transmission as corona losses, radio and TV interference and the best choice in the bundling, spacing and size of conductors.

Canadian General Electric has been awarded the contract to supply the transformers and bushings for this project. This contribution to an important research project is further conclusive evidence of the success of C.G.E.'s development-in-depth policy . . . a policy of continuous extensive research to help Canada's economy expand and Canadian technology progress.

Power Transformer Sales, Guelph, Ont.



Canadian General Electric designers confer on the preliminary outline of the new G-E transformers for Coldwater. The three single phase, 1667 KVA transformers will provide voltages in 2.5 KV steps from 205 to 605 KV, phase to phase. Relatively small, the tanks will be only 10 feet in height but the bushings will be 23 feet high and extend 18 feet above the tank cover.

GENERAL ELECTRIC

POWER TRANSFORMERS

Apparatus Department

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CANADIAN GENERAL ELECTRIC COMPANY LIMITED

FIFTY YEARS

OF

AERONAUTICAL ENGINEERING

A REVIEW OF CANADIAN PROGRESS

INTRODUCTION

by H. C. Luttman, Secretary, Canadian Aeronautical Institute

On the 23rd February 1909 the *Silver Dart* (Fig. 1), piloted by J. A. D. McCurdy, took off from the ice of Baddeck Bay in Nova Scotia and made a short and successful flight. The *Silver Dart* was built by the Aerial Experiment Association which was headed by Dr. Alexander Graham Bell; the other members of the Association were Glenn H. Curtiss,

• • •

This review has been written for *The Engineering Journal* by leaders in Canadian aeronautical engineering to mark the fiftieth anniversary of powered flight in Canada. Progress is recorded in the fields of: aerodynamics; structures and materials; propulsion; aviation electronics; ancillary services; and fabrication techniques.

Fig. 1 Above: The Silver Dart

an American engine expert, Lt. T. E. Selfridge, a U.S. Army expert on "aerodromics", and the two young Canadian engineers, J. A. D. McCurdy and F. W. (Casey) Baldwin.

The history of "first flights" is confused, partly because in the early days the definition of a "flight" was not clearly established—for example, a flight might not be recognized if it ended in a crash landing — and partly because everybody seems to have done their flying away from home. The first flight in England is credited to Col. S. F. Cody, who was an American citizen at the time; the first Englishman to fly was Henry Farman, who flew in France and whom everybody thought to be a Frenchman; and the first flight by a Canadian was made by Casey Baldwin at Hammondsport, N.Y. on the 12th March 1908. Despite the confusion, there is little doubt that the flight of J. A. D. McCurdy on the 23rd February 1909 at Baddeck was not only the first powered flight by a heavier-than-air machine in Canada but the first such flight made by a British subject in the British Empire.

The fiftieth anniversary of this historic event is being observed this year and it is interesting to look back at the progress in aeronautical engineering which has taken place in the meantime. From the *Silver Dart*, with a span of 49 ft., a gross take-off weight of some 750 lb., and an engine giving an intermittent 35 h.p., we have progressed to such aircraft as those appearing in Figs. 2, 3, and 4. Figure 2 shows the Canadair *Argus* maritime-reconnaissance aircraft, the largest aircraft ever built in this country, with a gross take-off weight of the order of 150,000 lb. Figure 3 shows the Avro *Arrow* fighter, capable of exceeding Mach 2—twice the speed of sound; the *Arrow* is powered by two Orenda *Iroquois* turbo-jet engines, each giving more than 20,000 lb. static thrust. Figure 4 shows the De Havilland *Caribou*, a fairly large utility transport with STOL (short take-off and landing) characteristics. All these Canadian designed and built aircraft are outstanding in their respective classes. Furthermore Canada has established a complete and almost self-sufficient industry to design and build the full range of aeronautical components and equipment.

Work has also been done in the new field of rockets and guided missiles but, with her relatively small resources of manpower, this country has made no effort to compete with others in this respect. If Canadian engineering achievements with manned vehicles offer any indication, no doubt the situation will be very different at the end of the next fifty years.

Aeronautical engineering is primarily mechanical engineering but it embraces almost every branch of engineering and touches almost every science. The sections that follow cover perhaps the major divisions of the subject. Each has been written by a specialist, who has endeavoured to cram fifty years of eventful and exciting development into the space allotted to him; he was indeed asked to get a quart into a pint pot.

Canadair photo

Fig. 2 Canadair Argus maritime-reconnaissance aircraft

AERODYNAMICS

by R. D. Richmond, Chief Engineer, Special Weapons, Canadair Limited

Reviewing the first fifty years of power flight in Canada from the time of the *Silver Dart* to the present, reveals the magnitude of the development that has taken place in the aeronautical sciences and their application. This growth is nowhere more evident than in the field of aerodynamics where research in theory and in the laboratory has made possible the rapid advances in performance and control of aircraft and missiles.

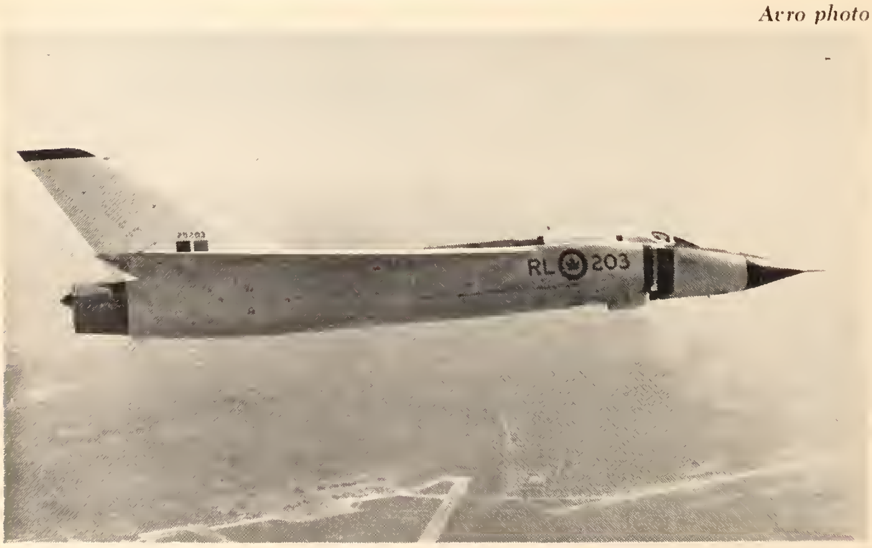
The earliest known Canadian research in aerodynamics, or in aeronautics, was undertaken by W. R. Turnbull. In 1902, seven years before the flight of the *Silver Dart*, he constructed Canada's first wind tunnel at Rothesay, N.B. (Fig. 5), and conducted tests on low-aspect ratio wings which he called "aeroplanes". Later from 1908 to 1911 Turnbull published three papers presenting his findings from theory and experiment on "aerial propellers". This work led to his investigation of the controllable pitch propeller on which he obtained several patents. These patents were subsequently licensed to the Curtiss Aeroplane & Motor Company, later to become the Curtiss Wright Corporation, who used them to develop the Curtiss Electric propeller, which is still currently in wide use.

In 1907 the "Aerial Experiment Association" was formed at Baddeck, N.S. for the purpose of conducting experiments in powered flight. The senior partner, Alexander Graham Bell, had become interested in this aspect of aeronautics through his experiments with kites. His work had attracted two young engineering graduates of the University of Toronto, Frederick W. Casey Baldwin, and J. A. D. McCurdy, and two Americans whose names became well-known in aviation, Glenn Curtiss and Lt. T. E. Selfridge of the U.S. army. The Association built a number of aircraft, the *Redwing* first flown by Baldwin, the *Whitewing* the first aircraft in the world to use hinged controllable wing flaps (ailerons), the *Junebug*, the *Cygnet II*, and the *Silver Dart*. Of these the *Silver Dart* piloted by McCurdy was the first airplane to be flown in Canada.

All the activity of this period, however, was not centred in the East. By 1907 the Underwood Brothers of Krugerville, Alberta, were conducting experiments and actually

Fig. 3 The Avro Arrow fighter aircraft

Avro photo



built an aircraft which had the appearance of a flying saucer; it never flew due to the lack of a suitable engine. Also, in 1910 Wm. Gibson near Victoria, B.C. built and successfully flew his *Twin-Plane* a configuration that consisted of two main planes in tandem.

From these early activities interest in aerodynamics as a science developed. Although several universities now have courses in aerodynamics, the University of Toronto, through the initiative of J. H. Parkin, was the first to offer one in their curriculum and to provide supporting experimental facilities. In 1917 he had established an aerodynamic research laboratory and constructed a wind tunnel having a working section of 4 ft. x 4 ft. with a velocity of 37 miles per hour. This was replaced in 1923 by a more efficient one having a velocity of 60 miles per hour which was used for many years in the instruction of students.

In 1949 this University formed the Institute of Aerophysics to train students and conduct research in the basic physics of gases, applied aerodynamics and ballistics in the field of supersonic flight. A supersonic wind tunnel having a working section of 16 ft. x 16 ft. for tests up to a Mach number of 3 was constructed for this purpose.

In 1929 the National Research Council built a wind tunnel in Ottawa with a 9 ft. diameter open working section giving a velocity of 230 ft. per second. This tunnel was the main aerodynamic facility available to government and industry until 1942. In that year a 6 ft. x 10 ft. closed working section tunnel having a velocity of 350 ft. per second was added and subsequently replaced the 9 ft. tunnel. It is now under the jurisdiction of the National Aeronautical Establishment and forms part of an aerodynamic facility that presently includes a spinning tunnel, a 10 in. x 10 in., a 16 in. x 30 in. supersonic tunnel (Fig. 6), and has projected a 5 ft. trisonic tunnel with operating Mach numbers from 0 to 4.5.

In 1951 the Canadian Armament Research and Development Establishment, a laboratory of the Defence Research Board, built an aeroballistic range capable of firing free flight models of missiles and aircraft up to a Mach number of 5.0. A smaller range capable of Mach 15 has since been added and others of different characteristics are planned. This facility, of great assistance in studying dynamic parameters, is not only unique in Canada but is one of few in the world.

De Havilland photo

Fig. 4 The De Havilland Caribou transport aircraft

The facilities are of course only the tools which have been used to develop aerodynamic knowledge. The application of this knowledge is manifest in the aircraft which have been designed or developed in this country.

The maximum speed versus time for some Canadian built aircraft is shown in Fig. 7. Although it is but one criterion, it is a good index of aerodynamic progress. The decrease in aerodynamic drag and the increase in wing loading which was made possible by the development of airfoils and lift increasing devices together made the largest contribution to this evolution.

This general summary narrates to some degree the Canadian development in the field of aerodynamics. It is not a static science, and to forecast the development for 50 years would be at least as difficult now as it was in 1909.

STRUCTURES AND MATERIALS

by F. R. Thurston, Acting Director, National Aeronautical Establishment

AT THE END OF the first 50 years of Canadian aviation, it has become a cliché to assert that these years have witnessed the greatest rate of scientific progress in human history and that a substantial part of this progress has been made in the aeronautical sciences of which Structures and Materials is a conventional subdivision. It is instructive, therefore, to remember that theoretical tools were available to the Aerial Experiment Association at the turn of the century for the solution of the structural problems that faced them and those who came after them. The natural philosophers of the 18th and 19th centuries had left behind momentous works on static structural stability, strength of materials, theory of vibration and theory of elasticity. These works, indeed, are to this day source references, and sometimes more, for the thousands of papers produced annually. In fact, the wealth of scientific theory that was available in 1909 has served as a placer mine for structures and materials research and development for 50 years and it is only in the last decade or so that new concepts and understandings have appeared, and these relate more to materials than to structures.

The essential theme of structures philosophy has always been and will continue to be the creation of structures of minimum weight and it is debatable whether the structures or the materials engineer has contributed more creatively to this enterprise. The structures analyst has tended to define his objective as the precise calculation of stresses in preconceived structures under known conditions of applied loading, environment, and constraint, and has added some sophistication by developing theoretical procedures for optimizing generic forms of design to provide minimum structure weight. In this, he has rather overlooked the more fundamental approach to his problem which lies in the determination of the least weight structure that will equilibrate a given system of applied loads.

The materials engineer has met, and partially solved, quite different problems. At the time the *Silver Dart* was built, the Hall process of producing aluminum metal had been known for 20 years, and duralumin alloy was available by the time of World War I. Since this time, several aluminum alloys susceptible to heat treatment have been developed and the course of structural developments has been most critically dependent on these materials. Many generations of aircraft have relied almost completely on the tensile aluminum alloys for primary structure and it is only recently in the more advanced-performance aircraft that parallel developments in high tensile and stainless steel and magnesium and titanium alloys are contributing to the solution of minimum weight or kinetic heating problems.

The theory of structural analysis has kept reasonable pace with the need for more refined analyses of aircraft structures. Up to about 1940 it was customary to analyze by what has come to be called Engineer's Theory. The essence of this process was to disregard the fact that the aircraft was a continuous three-dimensional elastic body and to make the necessary arbitrary assumptions to permit the analysis of the components separately by elementary shear, bending moment, and torsion equations. To this was added the development of methods based on the minimal principles and the principle of virtual displacements and these provided the analyst with powerful tools for the solution of statically indeterminate and structural stability problems. With the advent of electronic digital computers it has become possible to solve very large matrices very rapidly, and as a result it has become preferable to formulate two-dimensional problems in a tractable and more rational form and to solve them by numerical manipulation.

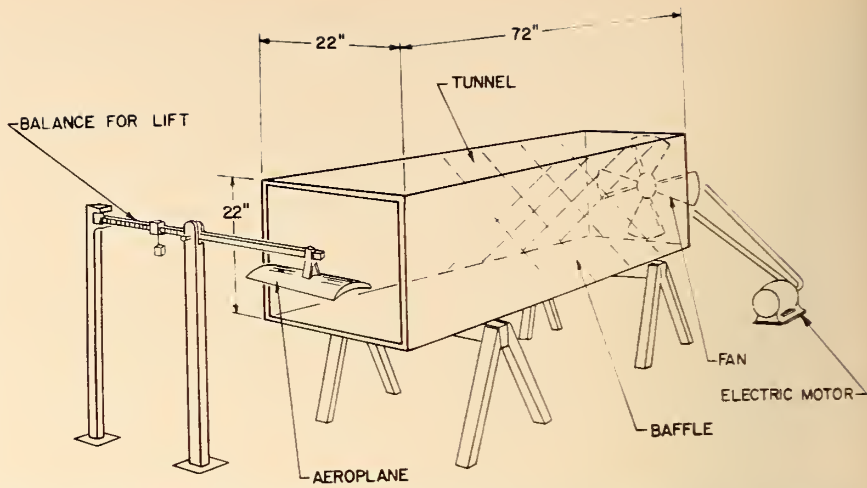
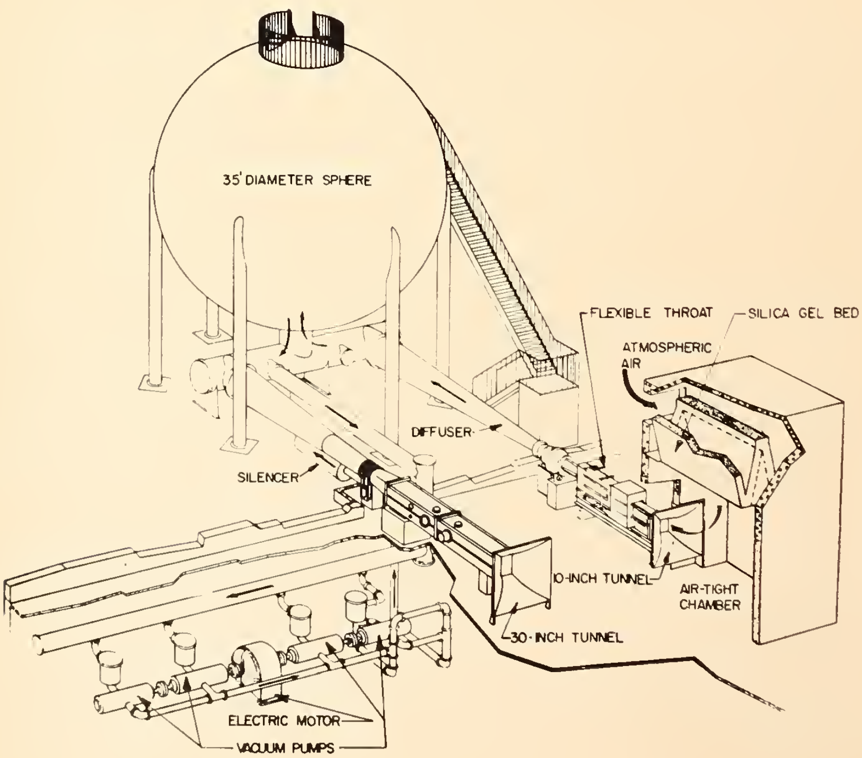


Fig. 5 Turnbull's wind tunnel 1902. Tunnel air speed: 10 mph (based on information from Turnbull's report "Researches on the Forms and Stability of Aeroplanes". Phys. Rev. Vol. XXIV March 1907).

While these theoretical advances have done much to sustain the analytic art, some very great changes have taken place in the complementary field of structure testing. Both the precision and complexity of modern structure tests stem largely from developments in the instrumentation field which have led to a truly astonishing variety of transducers. These transducers are used both in flight testing to attest the accuracy of the applied loading and in the static structural testing in the laboratory to check the static strength and the validity of the assumptions of the analytic theory. Here again, however, the most extravagant process of load and structure verification is primarily a proof of the strength of the structure and does little to establish minimum weight design.

Fig. 6 High speed tunnels at the National Aeronautical Establishment. Tunnel capability: Mach 4 (NAE Rep.; "Symposium on High Speed Aerodynamics," Fig. 1, p. 68.



In recent years there has been a change in the importance of criteria from the concepts of structure static strength to criteria of aeroelastic stability and fatigue strength, and the change has involved a dependence on theoretical flutter prediction and flight flutter testing and expensive empirical studies of the fatigue resistance of structural components. These additional design considerations have added to the difficulty of designing for maximum structural efficiency.

The future of aircraft structure design is beset with new problems which are additive to those still unsolved. The kinetic heating problem is as challenging to the materials engineer as it is to the structural designer or analyst and, although some experience has been gained in the effects of programmed loading, the superimposition of programmed heating introduces a complexity which will need great efforts to resolve. Perhaps the greatest rewards are to be found in the study of high temperature resistant non-metallic or cermet type materials and in the application of high speed digital computers to structural analysis and weight control.

PROPULSION

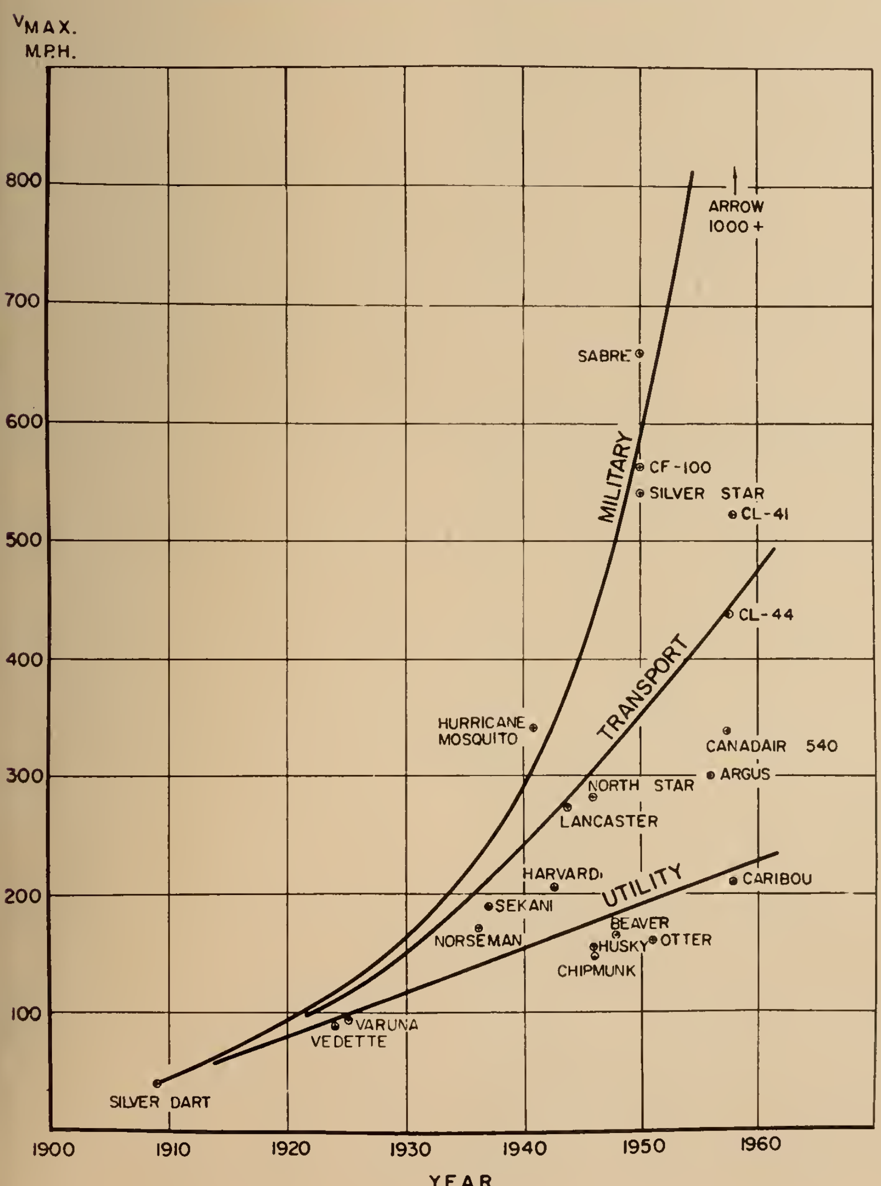
by F. H. Keast, Chief Engineer, Orenda Engines Ltd.

SOME WORDS WOULD BE appropriate with respect to the importance of aircraft propulsion in the affairs of the country. In all the branches of engineering there is probably none that approaches the aeronautical field in the necessity for the engineer to work so close to the bone. As weight is all-important there is no room here for large safety factors to cover ignorance. At the same time reliability is literally a life or death matter and the inspection methods applied must be of the highest quality. This means that knowledge must be precise on the part of the engineer with the minimum of "fluff factors" to cover ignorance. In fact, the aircraft industry, more than any other, can be taken as an index of the technological progress of a nation. At the bottom of the scale we have nations that consist of hewers of wood and drawers of water, and at the top end of the scale we have the precision engineering required of a country capable of designing aircraft.

How has Canada fared during the past fifty years?

In the early days of Canadian aviation, the name of W. R. Turnbull stands out and it was he who first imported, in 1906, an aircraft engine into Canada. This was a two cylinder "Duryea" engine (Fig. 8). This was actually for the purpose of driving airscrews to propel a hydroplane boat. The second step of providing the vehicle with wings was never achieved. The engine managed to destroy the propellers. This engine is now at N.R.C., Ottawa. It should also be mentioned that Turnbull did a good deal of important pioneer work on propellers and in fact invented the variable-pitch propeller. Another imported engine was the Curtiss engine (Fig. 9) of the *Silver Dart*, that made the first powered flight in Canada in February 1909. However, in the space available it is necessary to confine ourselves to engines designed and built in this country.

Fig. 7 Increase in maximum speed of Canadian built aircraft



We will skip quickly over the activities of the Underwood brothers, who drove model aircraft with elastic bands and weights on a drum which rotated the propellers, and also the initial efforts of W. W. Gibson, who in 1903 to 1904 used a window-blind spring in order to drive the propeller for his models. But Gibson, having bought a goldmine for $100 plus some chattels, managed to dispose of the mine for $10,000. This gave him the opportunity of continuing with an aero-engine of his own design which he had started a year or so earlier. In 1908, the 4-cylinder, 6-inch stroke engine was running, but was found to be of little use because of the high vibration. Even so, the completion of this engine was quite an achievement, since it was almost entirely handmade, a fact which was possible because of Gibson's earlier training as a blacksmith. His next engine was a 6-cylinder air-cooled motor and was arranged to drive two propellers, one in front of and the other behind the engine, in order to overcome torque reaction. Both propellers were 6 ft. in diameter and two-bladed. The front one rotated at engine speed and the rear one was geared to rotate at twice the engine speed in the opposite direction. It was completed in 1910 and ran extremely smoothly, developing 60 h.p. with a weight of 210 lb. The engine was installed in Gibson's *Twin-Plane* and had gravity feed from two fuel tanks, one on either side of the engine and well above. The aircraft made a short but successful flight on 8 September, 1910. Sixteen days later, it made a flight of 200 ft. which unfortunately ended in disaster, the machine suffering serious damage. The same engine was used for the Gibson *Multi-Plane,* which flew about a mile before landing on rough ground and suffering damage which forced Gibson to retire from aeronautics.

Canada was not involved significantly in the design and manufacture of aero-engines until 1943, when it was decided to look into the jet engine business and a Government technical mission was sent to the United Kingdom. In 1944, the National Research Council set up a cold weather test station at Winnipeg to test British jet engines. In the same year a Crown Company, Turbo Research, was formed and it was here that preliminary studies were made which led to the concept of the TR 4 (*Chinook*). The *Chinook* was an engine designed and built by the Gas Turbine Division of A. V. Roe Canada Limited which was formed in 1946 and later became known as Orenda Engines Ltd. It had a 9-stage axial compressor and single stage turbine with a specification thrust of 2690 lb. However the requirement for the engine changed before the engine was built. The TR 5 (*Orenda*) was ordered to give a thrust of 5500 lb. and the possibility of uprating to 6500 lb. At this time, great doubts existed in official circles of the ability of Canadians to produce such an engine. The competitors, in the U.K., were the Rolls-Royce *Avon* with 6500 lb. and the Armstrong Siddeley *Sapphire* with a similar rating. It was decided to proceed with the manufacture of the first three *Chinooks,* which really amounted to two engines plus one set of spares, in order to give the Canadian team an opportunity of testing an engine earlier than they could have if the *Chinook* order had been cancelled.

The *Chinook* design was really conservative; it had to be in order to provide an engine which would run and meet the specification, since the whole future of the Canadian aircraft industry hung on its fate. As a result of this, the *Chinook* produced a thrust of over 3000 lb., as against the 2690 lb. specification, and gave a promise of thrusts up to 3400 lb. As affairs in Canada seemed to work from one fiscal year to another, it was fortunate that the *Chinook* made its first run on 17 March, 1948. This ensured, for at least one year, the continuation of the engine industry in Canada.

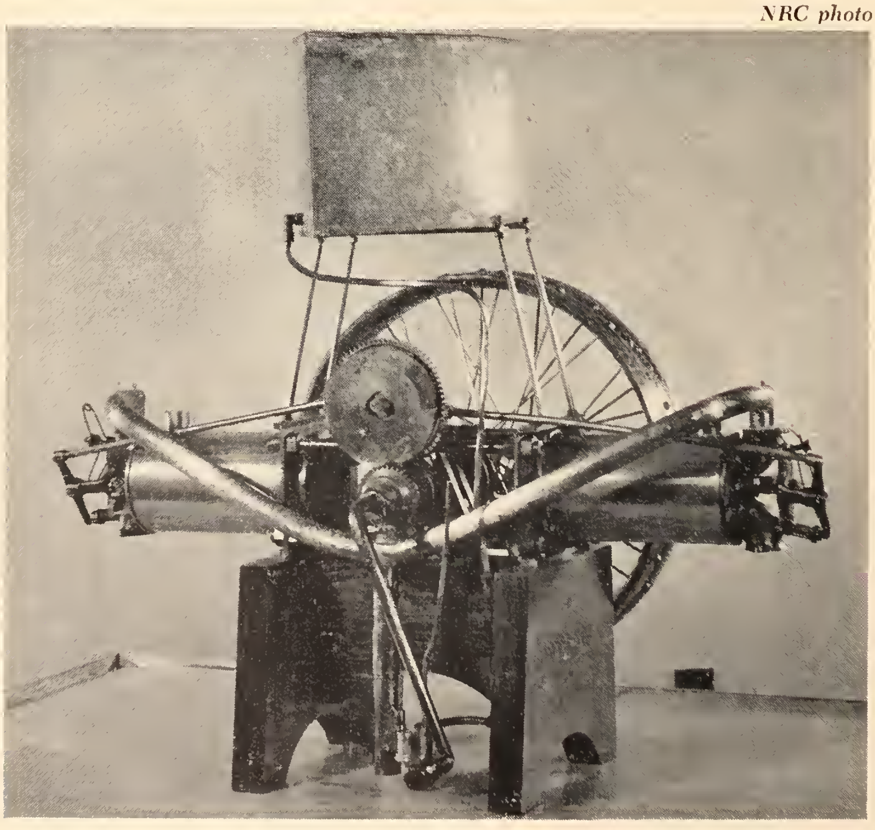
Less than a year later, on 10 February, 1949, the *Orenda* engine was first started on the bed. The engine exceeded its specification of 5500 lb. thrust very early in the development program and, in 1952, a factory specially built to produce the *Orenda* went into operation. The first production engines produced a thrust of about 6300 lb. This engine was known as the *Orenda* 2. The main defect in the *Orenda* 2 was rather sluggish handling, acceleration from idling to take-off being of the order of 18 seconds. After the first hundred engines, improvements were made to the compressor, which resulted in quite acceptable handling characteristics; this engine was known as the *Orenda* 8. Following this came the *Orenda* 9, which differed from the 8 mainly in its plumbing, allowing the engine to be used either as a starboard or port engine for the Avro CF100. (*Orenda* 8 had been handed engines.) In addition to the *Orenda* 2, 8, and 9, the *Orenda* 10 went into production in December 1952 to power the Canadair-built F86, later to be known as the *Sabre* V. This again differed from the 8's and 9's only in detail, having an aircraft-mounted rather than an engine-mounted oil tank and a bleed in order to provide an ejector action for scavenging the aircraft fuselage.

These early *Orenda* engines incorporated a single-stage turbine, which was heavily overloaded for the pressure ratio of the compressor. For some time it had been recognized that a 2-stage turbine was necessary in order to allow the *Orenda* to produce its full potential and, in March 1954, a 2-stage turbine was introduced giving rise to the *Orenda* 11 and 14 engines to power the CF100 and F86 respectively. Considerable compressor improvement had been developed on rig test during this period but its introduction awaited the 2-stage turbine. The net result of the 2-stage turbine and the compressor improvements was an engine which had a minimum guarantee of 7275 lb. thrust and a specific fuel consumption 15% lower than the single-stage turbine engines. At the same time, the weight was decreased from 2640 to 2360 lb. and fabrication methods were used for the turbine stationary parts as against the older method of casting.

Further engineering studies indicated that considerably more power could be produced from the *Orenda* engine. However no approval to put these measures into production was received on the grounds that, firstly, the F86 intake duct was limiting on mass flow, and, secondly, the CF100 was limited in altitude by buffet and not by power. Subsequent improvements in the CF100 removed the buffet ceiling completely and the air-

Fig. 8 The Duryea engine

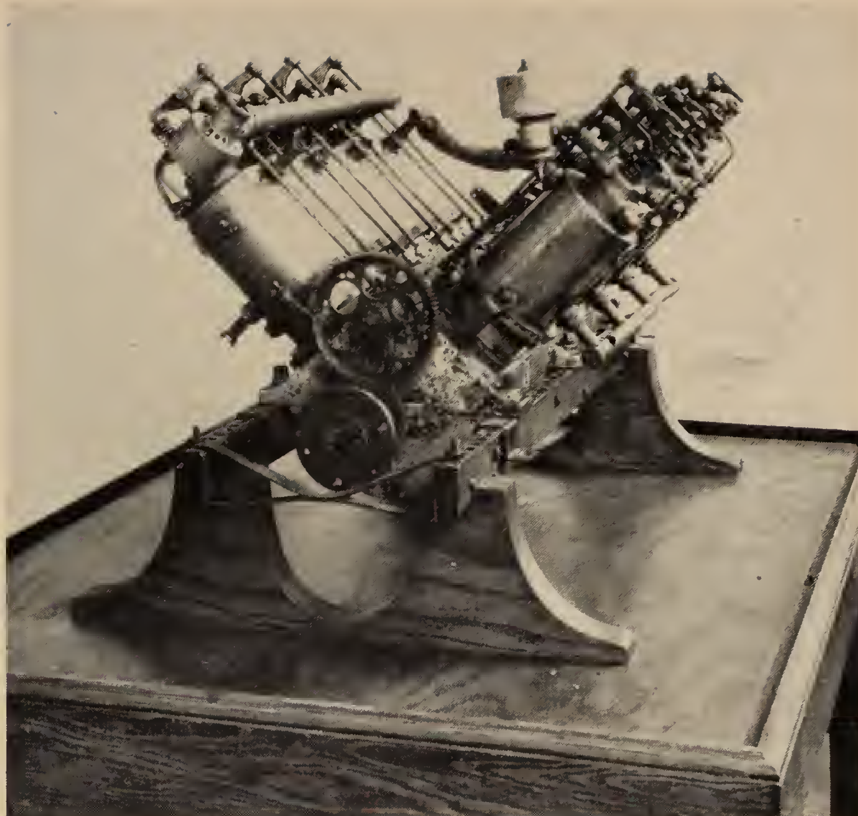
NRC photo



craft became power-limited rather than buffet-limited. By this time, it was too late to change the engine policy and the potential 8500 lb. trust engine was therefore never undertaken. The *Orenda* finished up in its present form, producing an average of about 7450 lb. thrust. The number of engines produced for the R.C.A.F. was 3376 and for foreign countries 380 giving a total of 3756.

Some time in 1953, the *Arrow* concept was accepted and this time, in certain quarters of the Government, there was an idea that engines could be bought off-the-shelf. The aircraft engine industry in Canada did not accept this idea and believed that an engine could be produced which would give more thrust for less weight than any off-the-shelf engine. In this way, the *Iroquois* (Fig. 10) was born and in September 1953 this engine proceeded as a private venture. In December 1954 this engine was on the test bed and running. Government support followed. The *Iroquois* is an engine conceived to give 30% more thrust than the best U.S. competition for a considerably lower weight. The result is an engine which can give the *Arrow* better range and performance in any possible mission than could any existing engine.

This is what Canada can do in this age of precision engineering and technology; though it was a late starter, it has quickly established itself among the foremost of the world's aero-engine producers.



NRC photo

Fig. 9 The Curtiss engine originally installed in the Silver Dart

AVIATION ELECTRONICS

by Air Vice Marshal M. M. Hendrick, RCAF, Chairman, Canadian Joint Staff, Washington

It was not until shortly before World War II that there was any significant Canadian development in the field of electronics or electrical equipment for aircraft. Prior to that time, the RCAF had used World War I British pattern radio equipment in support of its photographic operations in the Canadian north, while most commercial operators and bush pilots had no radio whatever. In the late 1930's, the Department of Transport commenced to build the Trans Canada Airway, supported by low frequency radio ranges. This equipment however, came primarily from American factories. During the same period the RCAF used later pattern RAF equipment for its Army cooperation and fighter aircraft, but this equipment did not differ very markedly in design or sophistication from the late World War I types, nor was it possible to get spare components or industrial support in Canada.

The twin factors of obsolescent design and inability to depend on logistic support led the RCAF to initiate the Canadian design and fabrication of a family of radio equipments which marked the beginning of original work of this type for Canadian industry.

Fearing that the supply of crystals in wartime would be critical, equipments were designed to have the same frequency stability that crystals would provide but to be tuneable throughout the band. They were also designed to be readily tuned by "rule of thumb", with a minimum number of knobs and to have a single meter which, by switching, could monitor the circuits in the equipment. They were to be remotely controlled, to provide the normal types of transmission (CW, modulated tone and telephony) and to incorporate direction finding. In addition, they were designed for installation in aircraft and therefore had to be extremely light for their power and extremely rugged in terms of ability to withstand vibration, shock, temperature and altitude changes.

The first of these equipments were called AT1 and AR2 (Fig. 11), designed and fabricated by the Northern Electric Company. They represented as radical a departure from the previous equipments as the all metal monoplane did from the previous fabric-covered biplanes.

The first test flight of the prototypes was made in a Noorduyn *Norseman*, flying from Trenton to Montreal on 24 January 1940, and the equipment went on to prove itself and was made in large quantities to support the Commonwealth Joint Air Training scheme.

A ground transmitter was designed and built by RCA Victor and called the AT3 (Fig. 12). Though not as difficult an engineering problem as the airborne equipment, it nevertheless represented some very advanced thinking in terms of frequency control, frequency stability, and remote control. It was certainly the first Canadian transmitter to be controlled completely from a remote position by a telephone dial.

A companion airborne set called the ATR5 (Fig. 13) was designed and built by the Canadian Marconi Company particularly for Army cooperation aircraft — it was the first compact transmitter/receiver to be designed and built in Canada. These pioneer efforts represented the first and last time Canadian industry was given an opportunity to develop original electronic equipment for military use.

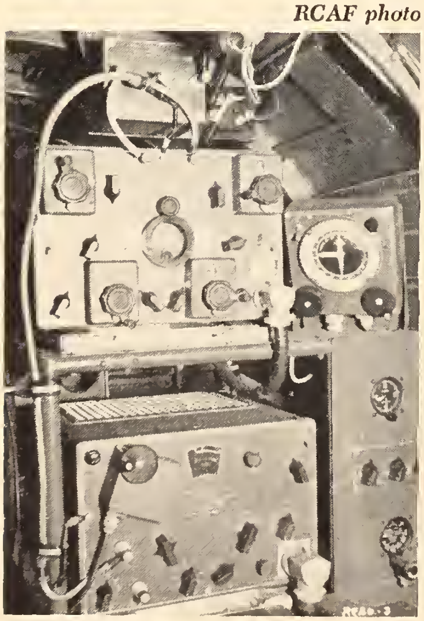
Once the vast resources of the United States were turned to the problem of producing the myriads of devices necessary for both civil and military use, the variety became so great that it was not economic for the Canadians to fabricate their own original equipment designs and the trend to purchase our requirements from the United States or to fabricate their patterns under licence set in and has been the standard practice ever since.

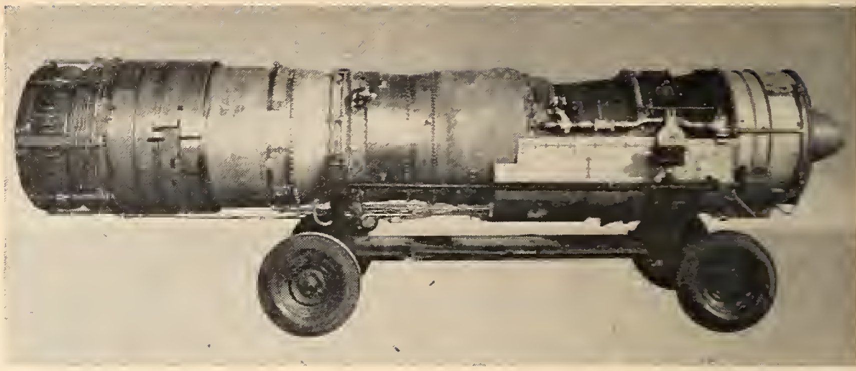
Canadian engineers also made significant contributions from the beginning of the war in the field of radar. Although these contributions were not necessarily ones of original design, they did involve the re-engineering of basic British designs and their fabrication in large quantities. Research Enterprises was the pioneer crown company which made the first early-warning radars in Canada. Enough of these equipments were fabricated to build Canada's early warning chain which remained in being for the duration of the war and then was immediately dismantled and abandoned.

At the same time, Canadian industry became involved in supplying airborne radars for the anti-submarine war. These were the famous ASV equipments (Fig. 14) designed and fabricated by the British in the first instance, and later manufactured to Canadian standards at home. A large number of these sets were constructed and about 150 patrol aircraft (of various types) were equipped with them at one time toward the end of the war.

Fig. 11 The first Canadian designed and built general purpose airborne radio transmitter and receiving equipment, AT1 and AR2, showing the transmitter with its universal tuning meter in the middle, the receiver with its remote control volume cable attachment to the tuning unit and the direction finding dial which controlled a loop direction finding attachment which use the aural null method.

RCAF photo





Orenda photo

Fig. 10 The Orenda Iroquois turbo jet engine

During this period, the National Research Council was one of the mainstays of Canada's radar effort. By modifying British designs and by original work of their own, they provided for the RCAF an IFF system and a beacon system, and toward the end of the war were working on original micro-wave radars (Fig. 15) which were intended to close the mouth of the St. Lawrence against submarines. These first micro-wave radars arrived too late for their primary role but they found their way into the role of tracking thunderstorms, and were used in pioneer work of what is now known as weather radar.

The beacon system was a 200 megacycle transponder, triggered by the airborne ASV equipment, which gave the aircraft distance and homing information. In 1946 the N.R.C. followed up this development by an airborne meter presentation attachment designed to operate with these beacons to meet the requirement then being generated by civil aviation for a pilot-operated navigation and fixing aid. The system was flight tested and proved excellent in measuring distances to 100 miles away and also in giving bearing, but it was subject to intense competition from other allegedly more sophisticated systems which were advocated very loudly by both American and British interests. The Canadian development was allowed to wither on the vine and it is interesting to observe that today no Canadian aircraft carries DME (distance measuring equipment) and we are still waiting for the installation of TACAN, which is the eventual outcome of those competitive systems promised in 1947.

The post-war build-up of our air defence system provided stimulus to the electronic industry in the logistic support, servicing, maintenance, and overhaul of the technical radars and communications equipment fitted in the CF100 and the *Sabre*. The radar gunsight in the *Sabre* was actually redesigned by the Canadian factory and an improved version, which gave greater performance for less complexity, was fitted in the later models of the aircraft.

A related activity, in which Canada has done some first class pioneer work in the last ten years, is in the field of the airborne navigational computation, which, though not electronic, is a combination electro-mechanical device to solve the dead reckoning problem. The "position and homing indicator" (PHI) and the R-θ computer are two cases, one for the single-seater and one for the multi-seated aircraft in which novel techniques were employed to produce reliability and accuracy in a minimum weight and size. The most complex example is the ANTAC system designed for the *Argus* anti-submarine aircraft.

During the last seven years, Canadian industry has branched into the airborne missile field with a training project sponsored by the Defence Research Board to develop the *Velvet Glove* air-to-air missile. Although the missile in performance was overtaken by advancing technology in the United States, nevertheless its development and testing in Canada proved the capability of the industry to design and fabricate the type of components required to meet the very rigid demands of modern missilry.

Since it commenced active original work in 1938, therefore, it is safe to say that the Canadian electronic industry has shown its ability to compete with the modern demands of military and civil aviation, but the opportunities to demonstrate this ability fully have been limited to the few cases where Canadian demand for numbers was large enough to support the project.

ANCILLARY SERVICES

by R. B. McIntyre,
Assistant Engineering Director,
De Havilland Aircraft of Canada Ltd.

THE AERIAL EXPERIMENT ASSOCIATION was founded specifically to construct an aircraft that could fly under its own power, carrying a man. The *Silver Dart* did just that — proving that man could guide himself about in an airborne vehicle. For a while this was quite enough; time was needed to learn about the art and science of flight itself. The technical step was great and the very adventure of flying was sufficient unto itself. In that period there was only one requirement for an aeroplane, namely, that it could fly.

As the techniques of aircraft design and operation improved, men soon combined imagination and ingenuity to direct the aeroplane into channels of usefulness both for military and civilian purposes. When people are asked to spend any length of time in a vehicle they expect to have safety devices, labor saving devices, and comfort. All this gave rise to ancillary services and accessory equipment. By definition, an ancillary service is subordinate to the prime functions of flying. The failure of any ancillary should not bring about catastrophic failure of the aircraft, but with the growth of ancillary services on today's large high-speed all-weather aircraft this may not be strictly true. Today we must regard many ancillary services as integral parts of the whole aeroplane and not merely as attachments put there as an afterthought.

An aeroplane consists, essentially, of an airframe, engines, ancillaries, and accessories. The ancillaries and accessories may be divided into those pertaining to flight, commercial or military use, and comfort. Thus an aeroplane's operational requirements dictate its necessary ancillary equipment and it is a fact that no modern aircraft can perform its proper function without the help of suitable ancillary equipment.

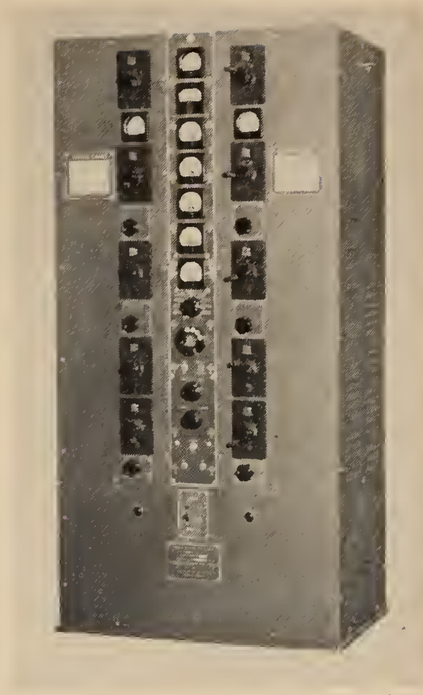
While the general term 'aircraft equipment' includes flight and engine instruments, navigation instruments, communication and navigation electronic equipment, these things are not usually regarded as ancillaries although in certain cases they derive their power from ancillary power services.

As aeroplanes grew in size and speeds increased, it became necessary to operate certain parts of the machine by a power source other than the pilot. Initially, it was a matter of relieving the pilot of distracting burdens, but later the work load exceeded human capability. In other cases the size of the aeroplane made the design of remote mechanical controls awkward, and power actuation was more desirable. The following is a list of some components operated by power on a modern large aircraft:

Main landing gear and doors; nose landing gear and doors; nose wheel steering; wheel brakes; air brakes; main wing flaps; cargo doors; armament system doors; windshield wipers. Such devices usually require only intermittent linear actuation.

As opposed to control or actuation there are other components or equipments which also require power. Such things as: engine starters; wing and tail de-icers; fire warning and extinguisher systems; lighting of all kinds (cockpit, cabin, navigation, landing, anti-collision, etc.); instruments (flight and navigation); electronic equipment (communication and navigation); windshield de-icing; automatic pilot equipment; cabin pressurization and air conditioning; galley services; armament systems. Obviously this list can grow with each additional end-use of an aeroplane, e.g., photographic survey work, agricultural work, etc.

Hence, we see that the majority of ancillaries involve us in considerations of powered systems. In certain obvious cases the aircraft designer has no choice but to use electrical power. In many cases there is a choice between electrics, hydraulics,

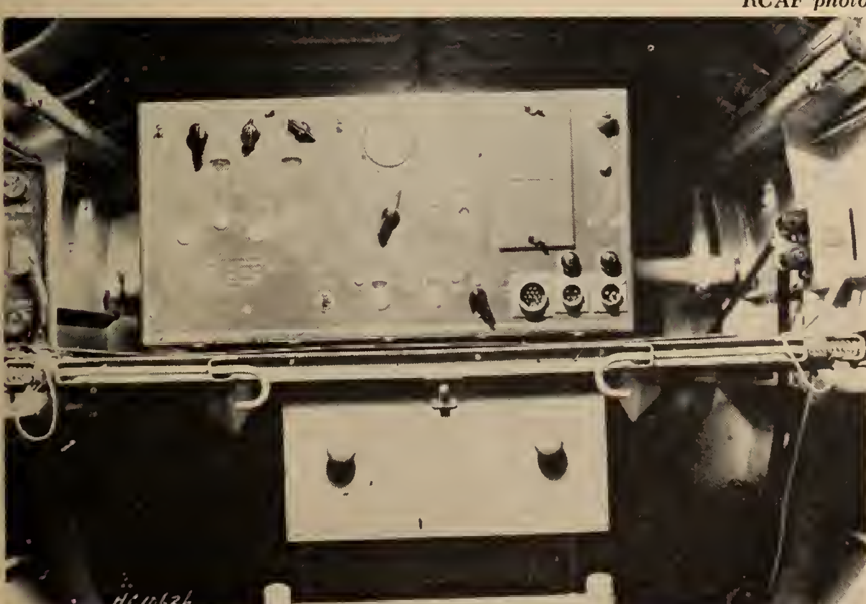


RCAF photo

Fig. 12 General view of the AT3 ground transmitter

Fig. 13 The first Canadian designed and built airborne transmitter receiver in one chassis, the ATR5.

RCAF photo



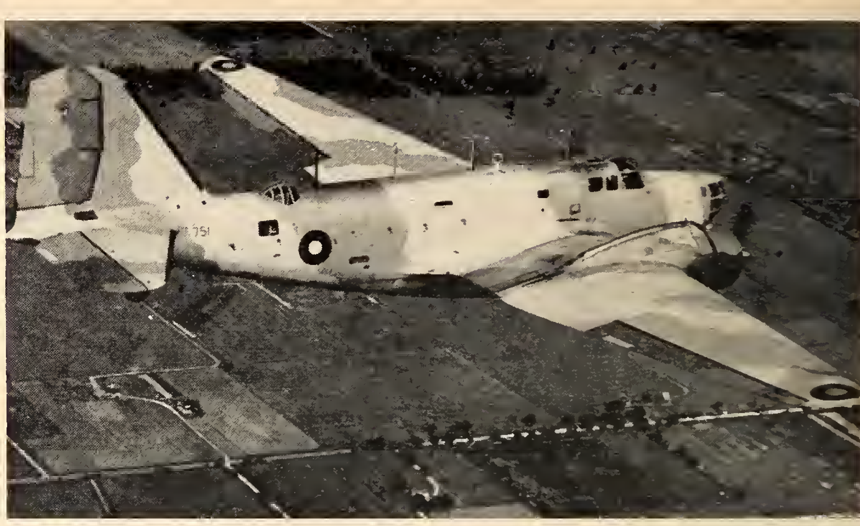
and pneumatics. Some aeroplanes have all three systems, each devoted to specific functions and occasionally one acting as a standby for another, such as a pneumatic emergency system on an undercarriage hydraulic actuation system. Today there are many specialist firms in the aircraft equipment field and the aircraft designer has a wide choice of electric, hydraulic or pneumatic equipment. The growth of this associated specialist industry has been of great help to the aircraft designers inasmuch as it has provided the aircraft firms with equipment to aircraft standards of safety, reliability, weight, and bulk at a reasonable cost.

The electrical system is probably the principal ancillary service on aircraft today. The growth of the aircraft electrical and electronic industry is a good index of this, and it is a fact that electrical power generation on aircraft has gone up rapidly in recent years. It is not unusual to find aircraft with total generated power output of several hundred kilowatts. Both DC and AC systems are used to supply starters, lighting, electronics, instruments, actuation motors and linear actuators, solenoids, heaters, cookers, air conditioners, and so on. While most aircraft use engine-driven generators or alternators, there is a development toward completely independent turbo-driven generators and alternators, particularly for the supply of constant frequency AC power. The use of DC rotating equipment becomes more difficult in high altitude jet aircraft.

Today, as for many years past, the battle is still waged on the relative merits of electrics versus hydraulics. There are some who favour the "one system aeroplane" which would, of course, have to be all-electric. However, the aircraft designer, who is always fighting the weight bogey, usually decides each issue on its own merits and, in most aircraft today, actuating power is supplied by both hydraulics and electrics. The pneumatic actuating system has gained much interest in the last few years in the U.S.A. although this system has a considerable history of development in the U.K. Many papers, by competent people, are available on the features and advantages of the various systems. In general, it can be said that high load actuators in the form of simple hydraulic jacks are consistently lighter than their electric-motor screw-jack counterpart even as an "installed" system.

On modern aircraft the power requirements are so high that it is important to decide on the general layout and types of powered systems at an early stage in the design. In other words, all systems (including the power plants) must be well integrated with the airframe. An example of this might be a jet propulsion engine compressor providing cabin air, cooled by a turbine which in turn drives an electrical generator and hydraulic pump.

Another major ancillary on modern aircraft is the cabin pressurizing and air-conditioning system. For many years both flight crews and passengers had to be contented with little or no comfort equipment and



RCAF photo

Fig. 14 Canadian anti-submarine aircraft fitted with ASV Search Radar. The aerial array is supported by four stub masts along the spine of the aircraft

Fig. 15 Aerial of the first Canadian designed and built micro-wave radar

Fig. 16 15,000 ton rubber forming press. Flat parts cut to shape by routing are formed under pressure to contour of form blocks

Avro photo

seemed to get along quite well. Since 1945 there has been considerable work done by designers and builders at least to minimize the discomforts of flying. Cabin pressurization is more recent and has now graduated from being a simple provision for passenger comfort on piston engine aircraft, to an essential system on high-flying jets. The jet aircraft's cabin pressure system must have the ability to withstand failure of any sort, but it must be noted that current jet transports provide emergency oxygen equipment for crew and passengers. The equipment for pressurizing and conditioning is quite sophisticated and has been largely developed by specialist firms working closely with the aircraft builders.

The small high-speed turbine wheel is on the way to becoming the heart of modern aircraft accessory systems. It made its entry as a means of cabin conditioning and pressurization and is now the main component of much more far-reaching systems. The ancillary jobs of which the small turbine is capable are so diverse that it can be the means for generating electric power, refrigeration, hydraulic pumping, air compression, and the production of mechanical torque. In effect this will provide large aeroplanes with a "power station" independent of the main propulsion units, which offers advantages in efficiency, flexibility, weight reduction, and reliability.

This brief review can only highlight the main ancillary systems found in modern aircraft, but to engineers it should indicate how aircraft engineering has broadened in scope over the last 50 years. Mechanical, electrical, and electronic engineering have become as important to the aircraft designers as the structural, metallurgical, and aerodynamic aspects of flying machines. The airframe constructor undertakes to provide and be responsible for the complete vehicle. It is, therefore, natural that the aircraft designer should be critical of the elaborate standard of equipment current today. He persists in his plea for the reduction of equipment weight and bulk. The design gross weight of an aeroplane varies almost linearly with the combined weight of payload, crew and equipment, that is, the fixed items required to be carried. Hence, a 10% reduction in these fixed quantities gives about 10% reduction in all-up weight. On a long-range aircraft the payload, crew and equipment may total only, say, 20 to 25% of the gross weight so that it can be seen that a relatively small sacrifice on the fixed items can yield appreciable savings in all-up weight and initial cost. Reduction in bulk of equipment reduces total aircraft volume and results in lower drag and higher performance. Of course, advantage can only be taken of such reductions if they are known early in the design stage.

As already mentioned, the equipment designers have done a great deal toward reduction of weight and bulk, but it is expected that the conflict between operational amenities and aircraft performance will go on into the future. The aircraft designer must control the ancillary equipment situation since it is clear that such equipment has a large influence on basic aircraft design.

It would appear that aircraft and ancillary equipment engineers have made good use of their time over the

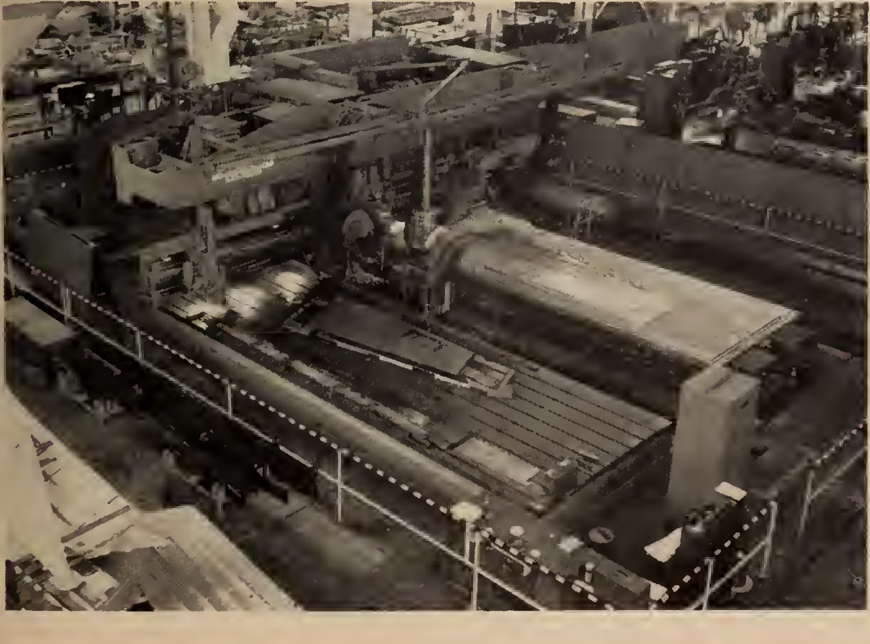
(Continued on page 79)

Avro photo

Fig. 17 Autoclave pressure chamber. Assemblies in vacuum bag are cured under pressure and heat after application of adhesive to joining surfaces

Fig. 18 Large wing skin being milled from solid billet of metal. Cutter head moves over material at right, guided by tracer following template at left

Avro photo



Engineering Features of the BEECHWOOD DEVELOPMENT

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THE BEECHWOOD DEVELOPMENT is located on the St. John River in the Province of New Brunswick, about 110 miles above the provincial capital of Fredericton (Fig. 10). Perth and Andover, on opposite sides of the river, are some fifteen miles to the north; Florenceville is about twelve miles down river. There are bridges across the St. John River at each of these towns.

The St. John River valley, in this vicinity, runs north and south parallel to the International boundary and some eight miles to the east. The sides of the valley rise gradually from the banks of the river in pleasant fertile terraces.

Under a reference of 7th July, 1952, the International Joint Commission commenced a study of conservation and regulation of the St. John River. Its report published in 1953 recommended the Beechwood site for initial development on the main stem of the river, pointing out that it is centrally located with respect to system load centres and lies below the Aroostook and Tobique Rivers, both of which have some existing storage. Additional storage on the upper reaches of the river, when built, will benefit the Beechwood plant.

Hydrology

The St. John River basin lies in northern Maine and adjacent Quebec and New Brunswick. The watershed of the St. Lawrence River to the north and that of the Penobscot to the south adjoin the basin. The total drainage area is 21,600 square miles, making the St. John one of the largest rivers draining into the Atlantic Ocean. Sixty-five per cent of the drainage area lies in Canada and thirty-five per cent in Maine. The total fall of the river between the source and tidewater is 1,578 feet.

Below the Grand Falls site (Fig. 10) the river drops 287 feet to tidewater. The river here is broad and slow-moving with many shoals and islands formed by the deposition of materials carried in suspension down the swifter reaches. The profile suggests that power developments will have low heads and long headponds typical of peaking plants. Dam sites are primarily to be selected for foundation and abutment conditions rather than from any features of the river profile.

The mean annual run-off of the river at Pokiok, below the Beechwood site, is 1.56 c.f.s. per square mile, equivalent to 21 inches in the drainage area. Approximately two-thirds of this occurs in the months of April, May, and June, although there is often a flood peak in the fall. During the period of record the run-off has varied from a minimum of 0.2 c.f.s. per square mile to a maximum of 17 c.f.s. per square mile. The latter run-off as measured at Pokiok corresponds to the record flood of 238,000 c.f.s. at Beechwood in May, 1923. As may be surmised, the St. John River is very flashy and might be expected to present some difficulties during construction.

Power Potential of the St. John River

There are four power sites on the main stem of the river in New Brunswick, of which only two are developed. These are Grand Falls with an installation of 57,000 kw. at 132 feet head and the Beechwood plant to be described in this paper. The two undeveloped sites are Morrill, situated about halfway between Grand Falls and Beechwood, and Hawkshaw, some forty miles above Fredericton. Morrill is expected to develop 66,000 kw. at 53 feet; Hawkshaw, with a head of 55 feet, will produce 112,500 kw. Comparative estimates at an earlier date had shown Beechwood to be the most economical development.

Beechwood Installation

The studies made for the Joint Commission report showed that 102,000 kw. could be installed at an average head of 60 feet. Additional studies were made during the planning stage of the development which confirmed the proposed installation and established that three units should be installed with a rating of 36,000 kw. at a net head of 57 feet. These studies also confirmed that, in relation to existing storage and system load, only two units should be put in initially with space provided in the powerhouse for the third.

The value of capacity in a system combining thermal and hydro power is very high. The Beechwood plant will be operated essentially as a peak load plant during periods of low flow and the thermal plants will be base loaded. The reverse will be true during periods when the flow is equal to or greater than rated discharge.

Backwater Studies

The construction of the Beechwood dam produces a backwater effect which extends for many miles up the river. Since the countryside is well settled, extensive provisions were necessary to protect the banks over certain reaches and to compensate for flooded areas at others. In addition, the effect on the future site at Morrill must be determined.

Perth and Andover are principal areas affected by the backwater. It was apparent that, for a particular river level at this location, various flood flows could be passed depending on the number of sluice gates provided at the dam, coupled with the permissible drawdown. Hence, it was necessary to prepare the curves of Fig. 1, which shows the relationship between water levels at Perth-Andover and those of the forebay for various flows. Superimposed on these is the capacity curve for nine sluice gates and two regulating gates. Similar curves for various numbers of gates were used in the course of the study.

The flatness of the curves indicates at once that a comparatively large variation in level at the forebay for flows in the neighbourhood of 238,000 c.f.s. produces a much smaller variation in the corresponding level at Perth-Andover. Since the forebay must inevitably be drawn down, the backwater effect at points in between is not critical.

Further study along these lines indicated that nine sluice gates together with two regulating gates formed a satisfactory installation. The installation of a larger number of gates would reduce the backwater at the towns by only a fraction of a foot for a particular flood flow, or, on the other hand, would increase the flood capacity by only a small percentage for a particular level at Perth.

Backwater calculations were made by the step method to the Morrill site. The curves shown in Fig. 1 were interpolated by the unit-fall method.

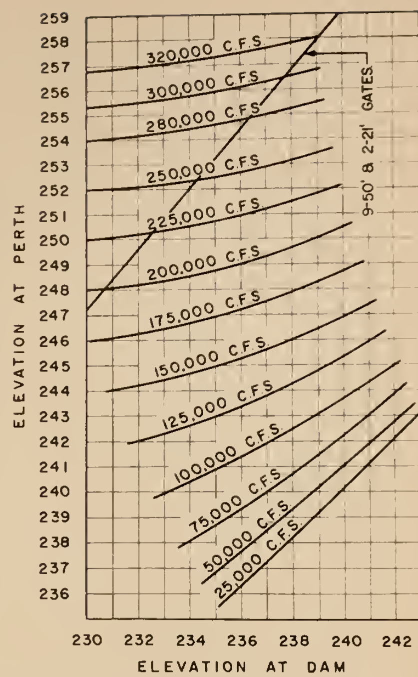


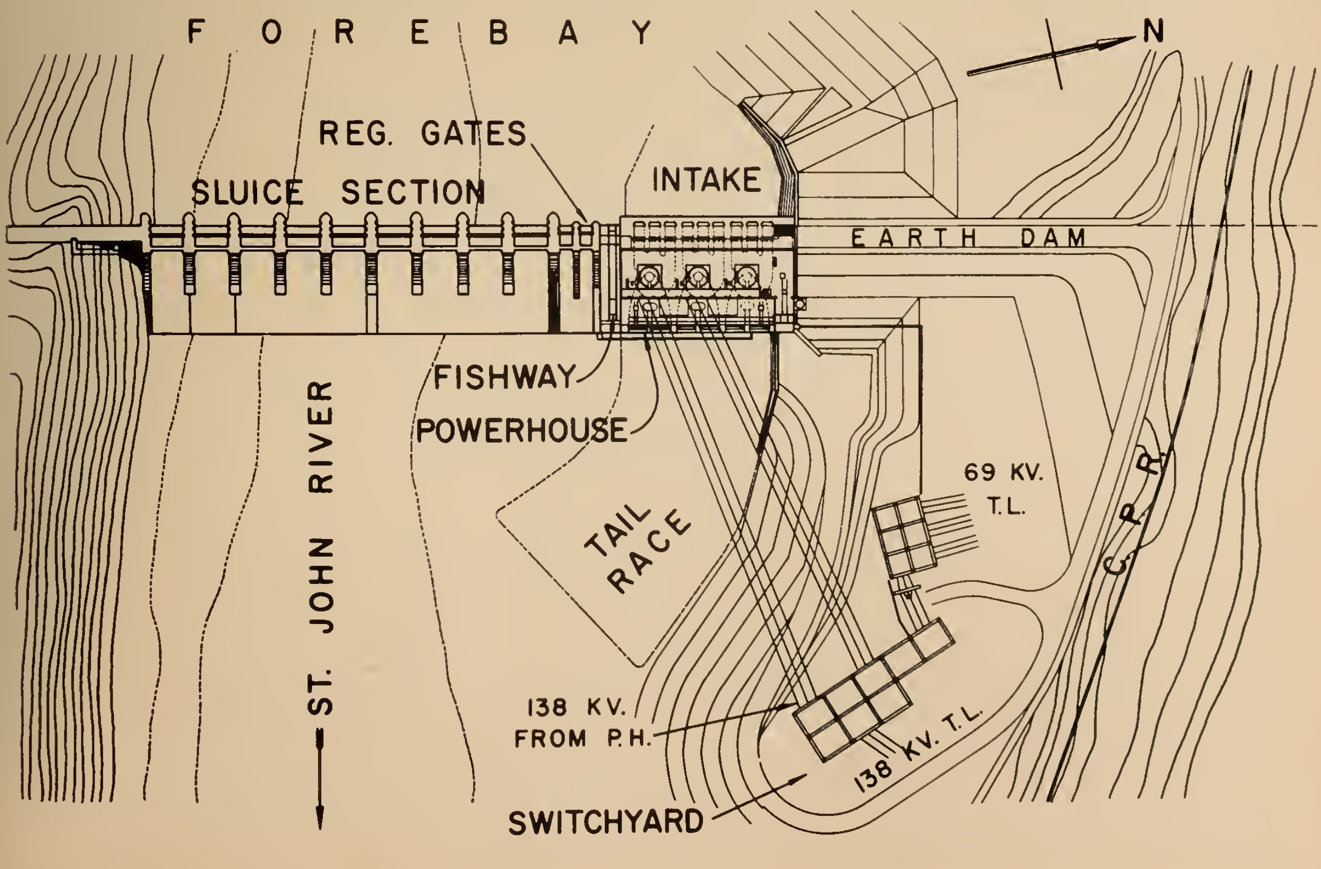
Fig. 1. Chart of backwater elevation between Perth and forebay.

Description of the Site

Three locations of base line were investigated in the field. These lay in a reach some 800 feet long, and the bed rock profile was ascertained for each by diamond drilling. After some preliminary study, the middle or "K" line was selected as the base line for the development.

On the west bank the rock rises steeply to form an ideal abutment for the dam. Though overburden was rather heavy, there was no great problem in removing it. Rock, in the bed of the river near the west bank, is deep, at approximately elevation 142, and is overlaid with thirty to forty feet of silt. Towards the east bank it rises and remains generally

Fig. 2. General plan of the development.



horizontal at about elev. 170. The east bank of the river consists of overburden—a pervious mixture of silt, clay, and sand. Rock for the east abutment reaches elev. 248, the crest level of the dam, some 600 feet back from the original bank. Since the overburden is pervious, a cut-off wall was required to abut on the rock. Bumfrau Brook, which originally flowed along the bank, was diverted into the St. John above the base line.

The railway had to be diverted to a higher level on the east side of the river before construction. Highway grade changes and relocations, and extensive bank protection were also required.

Geology and Foundation Treatment

The topography of the preglacial valley of the St. John River near Beechwood has been largely modified by ice action during the last period of Pleistocene glaciation and by deposition of detritus during the retreat of the ice. Valley trains were established, subsequent stream action modified these deposits to a varying extent, and the river has cut down to its present bed, which consists of a bouldery alluvium of varying thickness. Terraces of mixed gravel and silty till frequently rise abruptly from the water's edge up to 70 feet. Above these terraces the hillsides are thinly covered with silty stony till ("potato dirt").

This silty till is well graded and was used for the impervious core of the earth dam that forms the closure to the east of the intake. The deposit was shallow, the moisture content of the in-place material was above optimum, and compaction was difficult during wet weather.

The gravel deposits in the river terraces produced excellent coarse aggregate for the concrete when 10 to 20 per cent of the lightweight particles were removed. Sink float processing was used to upgrade the gravel.*

Bedrock at Beechwood is a calcareous shale or argillite. Locally cleavage is so well developed that the rock has a slate-like appearance and evidence of bedding has been destroyed. Small dykes and stringers of calcite with or without quartz cut or meander through the argillite. The weathered surface of the rock varies from grey to greyish brown; on fresh surfaces it was dark grey, and in the zones of more pronounced cleavage, shiny jet black. In several locations drilling encountered zones containing water under artesian pressure in the bedrock and in the overburden of the river bed.

The most highly developed cleavage was found in the powerhouse area where the deepest excavation was required. During blasting operations the rock opened up along the cleavage planes, which added to the overbreak and necessitated an extensive bedrock consolidation program in the intake-powerhouse area as well as a close spaced pattern of curtain grouting along the upstream face of the intake.

At pier 12 a fault zone of variable width, generally of the order of 1 foot, was uncovered that had a north-south strike and dipped at 45° to the east. This zone was filled with brecciated argillite, unbrecciated calcite and minor gouge. The structure was open for the passage of water. Excavation for the draft tubes encroached on the faulted area and it was necessary to remove a part of the hanging wall that was unsupported and replace it with concrete.

Due to the solubility of the calcite and the openness of this fault, an extensive program of grouting was required to consolidate the material and seal off all water passages.

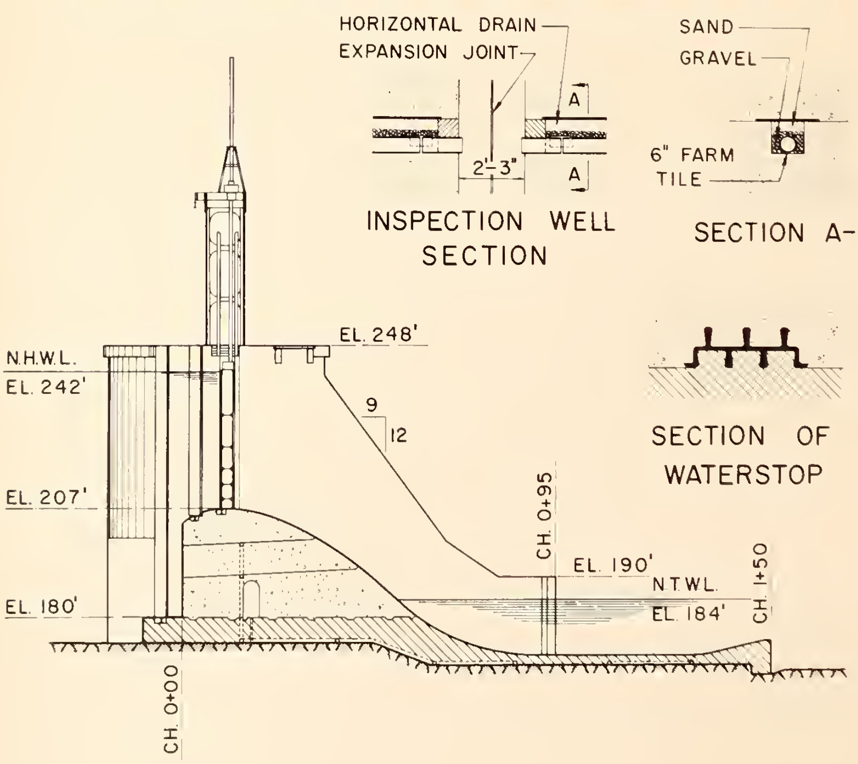
Extensive curtain grouting was necessary to establish a watertight cut-off extending to depth adjacent to the upstream face of the structures and along the upstream east retaining wall. Close spaced blanket grout holes to 20 feet depth were put down in the intake and powerhouse areas and under the east retaining wall to consolidate the bedrock distributed by blasting. In the fault zone at pier 12 both consolidation and curtain grouting were used.

In the western part of the sluice section the rock was relatively tight. A double row of curtain holes on 10-ft. centres to depths of over 100 ft. were required. East of pier 6 the rock was more open and three rows of holes with an effective spacing of 5 ft. were put down to a minimum depth of 100 ft. with test holes to 200 ft.

From pier 12 east across the intake, four rows of curtain holes were put down. The 45° east-dipping fault zone was grouted to 175 ft., below which it proved tight. Three rows of holes were vertical and one was inclined to the west, the effective spacing being approximately 2 ft. Both stage and step grouting was used in this area. Under the earth dam two rows of curtain holes were put down. Three rows of holes from 100 to 200 ft. deep were put down below the east retaining wall and extended downstream to the downstream face of the powerhouse.

In the intake-powerhouse area con-

Fig. 3. Typical section of sluice showing by-pass arrangements and seals.



*Heavy Media Processing of Gravels in New Brunswick, I. D. MacKenzie, Journal of A.C.I., Sept., 1958.

solidation grouting was carried out in two 10-ft. stages to a vertical depth of 20 ft. The primary pattern consisted of rows of holes on 10 ft. centres, the alternate rows being inclined 60° north and south. The second pattern consisted of holes intermediate between the first pattern with the alternate rows of holes dipping 60° east and west. Consolidation grouting to 20 ft. depth was also carried out under the core of the earth dam and under the east retaining walls.

Some 6,600 bags of cement were injected into the curtain grout holes and 3,500 bags of cement into the consolidation grout holes for acceptance of 11.3 and 1.5 bags per hole respectively.

Description of Structures

The final arrangement, Fig. 2, placed all the structures on a straight base line. On the west bank a concrete bulkhead section was poured against the rock, extending outward to the spillways which lie roughly in the centre of the river. The regulating gate section adjoins the spillways, and the fish hoist is between this and the powerhouse on the east bank. From the powerhouse to the east rock abutment there is a cut-off consisting of an impervious clay core blanketed by the local sandy material.

Spillways

There are nine spillways, each 50 ft. wide, with sills at elev. 207 corresponding to a normal forebay level of 242. Piers 15 ft. thick are raised to elev. 248, thus providing 6 ft. of freeboard. Two regulating gates each 21 ft. wide by 22 ft. high are also provided. The design allows the forebay level to rise to within 1 ft. of the top during an extreme flood.

For floods over about 100,000 c.f.s. the forebay is drawn down until a minimum pond level of elev. 230 is reached. After this, the forebay rises with the flood thus increasing the head over the sills. Table I gives some values of discharge capacity.

The historic flood is 238,000 c.f.s. or 17 c.f.s. per square mile. At maximum forebay level the run-off corresponding to the spillway capacity is 31 c.f.s. per square mile, which is considered a safe figure allowing for the flashy characteristics of the river.

The capacity of the two regulating gates is only slightly less than the rated discharge of two units; if load is lost on both units simultaneously, the gates can be quickly opened to control the forebay level.

Figure 3 shows the cross-section through the spillway. The sill shape

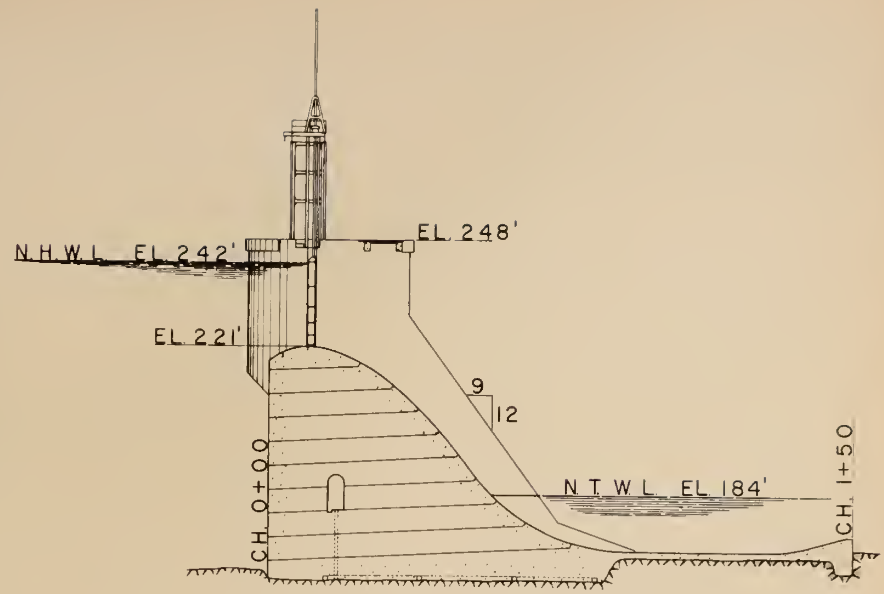


Fig. 4. Typical section of regulating gate.

is a scimimian parabola with vertex 10 ft. from the upstream face. Upstream of the vertex, the profile is a circle of 14 ft. radius with centre 9 ft. 6 in. from the upstream face, which is somewhat fuller than the theoretical true profile and is provided to allow for stop log gains and sill beams with clearance for working space in front of the gate. The complete profile was checked by model test to ensure that there is a positive pressure at all points on its surface.

A circle of 50 ft. radius joins the sills and aprons tangentially. The apron is a reinforced concrete slab of 18 inch nominal thickness extending some 150 ft. below the base line. At its lower end it sweeps up to a lip with a 10 ft. tangent length, making an angle of 14° to the apron surface. This lip serves effectively to prevent erosion of the rock at the toe of the apron, where there is quite a dissipation of energy. The apron elevations are varied to suit the elevation of bedrock except where the rock is very low. The drainage system is designed to prevent uplift on the slab due to high tailwater levels.

Expansion joints are provided on each side of the piers. Sills and piers are therefore designed to be separately stable, and reinforcing steel is placed through the horizontal pour joints to ensure safety of the sills against sliding. The sliding factor at the rock line for the composite structure (sills and piers) is kept low in view of the stratified type of rock.

The gates are 50 ft. wide by 36 ft. high, of fixed roller type, operated by individual screw hoists carried on steel towers and bridges. They are designed for an ice load of 5,000 lb./ft. width applied at any level from one to six ft. below the top of the gate. A monorail hoist, mounted on the upstream side of the towers handles the stop logs. The heating of the skin plates and gains of some gates for emergency winter operation is dealt with elsewhere in this paper.

To distribute the thrust of such large gates to the piers, presents a particular problem. Tower - type bedded parts were designed to support the gains, which are themselves completely formed in steel plate. Thus, mass concrete can be poured to embed the towers with no subsequent need to grout in the gains. The towers are also so designed that the load received by the gains is distributed deep into the mass of the piers. This results in an exceedingly strong arrangement and one not readily subject to concrete deterioration through spalling or erosion.

The two regulating gates are of similar design to those of the 50 ft. spillways. The sills were poured initially to the finished profile and are shown in Fig. 4.

Inspection Tunnel

An inspection tunnel in the dam, from the west bulkhead to the powerhouse, will permit inspection for leakage at or below the rock line and allow any necessary additional grouting to be done. Six-inch diameter pipes at 5-ft. centres are embedded in the concrete from the floor of the tunnel to the rock. Through these pipes a hole was drilled two to three feet into the rock foundation. Escape shafts are provided at three points along the tunnel rising to the tops of piers, and a portal is formed in the west bulkhead. All drains lead to the inspection tunnel which is provided with a sump and two 360 U.S.g.p.m. pumps operated by water level control.

Closure

The closure scheme to raise the water level in the forebay formed part of the design of the spillways. The sills were poured initially to elev. 180, the approximate level of the bed of the river and the piers to their final level. Stop log gains were built into the piers at the upstream and downstream limits of the sill. Three sets of steel logs were provided for the upstream gains while timber stop logs, reinforced by needle beams, were used in the downstream gains. The scheme called for closure of the openings in groups of three commencing at the west end and proceeding eastward. The flow of the river was to take place over the remaining sills. Of the final group of three, the first was to be concreted separately, then the remaining two simultaneously. Sufficient stop logs were available from the three sets so that these last two could be kept unwatered while the water was passed over the seven completed sills. The final closure was to take place at lower flows in late November or December.

Unwatering Scheme

The scheme for construction called for a cofferdam extending out from the west bank to enclose an area so that five sills and six piers could be poured. On completion, the cofferdam was demolished and the spring flood passed over the uncompleted sills and the remaining section of the river to the east, augmented by some bank excavation for the powerhouse. After the spring flood, a cofferdam was extended eastward from a section which sealed against a completed pier. This cofferdam enclosed an area to permit the pouring of the remaining sluices and part of the regulating gate section. This was to be completed before the fall flood together with a final cofferdam enclosing the powerhouse area, built to seal on the west regulating gate pier.

The St. John River is extremely flashy and calculated risks were necessary in reducing cofferdam heights so that the yardage could be placed and the necessary concrete poured between spring and fall floods. It was decided to provide for "between flood" flows of 40,000 c.f.s. and floods, either spring or fall, of 200,000 c.f.s.

Other conditions during the construction period included provision for passing the log drive and also the salmon run.

During the summer of 1954, while the design studies were progressing, very high summer flows were being recorded with peaks of over 90,000 c.f.s. This caused some concern to the engineers, but the flows during the actual construction period were con-consistently among the lowest ever recorded for the river. These extremely fortunate conditions led to some deviations from the original construction scheme.

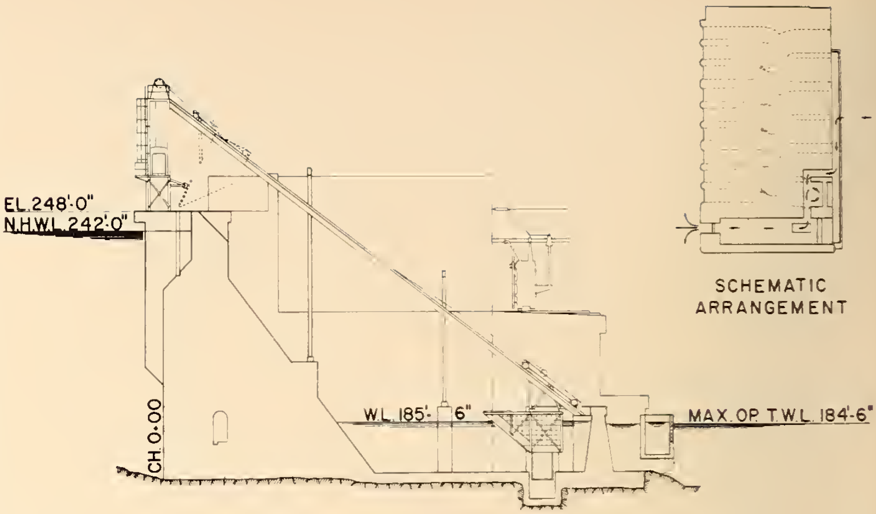


Fig. 5. Fish hoist arrangement.

Bubbler System

To reduce ice formation, a bubbler system is installed on each gate. Four nozzles equally spaced across the gate 12 ft. below the surface discharge air bubbles which raise relatively warmer water to melt any surface ice. Two 100 c.f.m. compressors supply the air.

Fish Passing Facilities

Each year, from May to November, the Atlantic salmon run up the river to spawn in the shallows of tributary rivers, principally the Tobique. Though the run is not of commercial significance, the value as game fish is great. It was therefore necessary to design facilities to get them over the dam at Beechwood.

During the run the salmon swim against the current, and this characteristic has been used to guide them. Since the flow from the draft tubes of the turbines forms an ideal attracting current, it is usually best to have the fish passage near the powerhouse.

A fairly conventional fish ladder is in use at the Tobique plant of the Commission, and it was at first proposed to build at Beechwood a similar reinforced concrete structure of alternating drops and rest pools conforming to a 1 in 12 slope. However, to build such a structure on the material of the east bank and to control settlement so as to maintain the slopes would be difficult and expensive, and an alternative method was designed. (Fig. 5).

Experience at Tobique showed that a gallery along the downstream face of the powerhouse above the draft tubes, with openings in its outboard wall, attracts the fish into the passages. This was incorporated in the Beechwood powerhouse as a gallery 8 ft. wide with three openings, each 6 ft. wide, provided with stop logs to produce a drop of 9 to 12 in. in the water surface to attract the salmon. At No. 1 unit the gallery turns in under the draft tube deck and leads to a rest pool formed in the west bay adjacent to the hoist. Adjustable louvres at the entrance and exit control velocities and deter the fish from returning downstream.

A flow of 12 c.f.s. was selected with provision for adding additional

Table I. Values of Discharge Capacity

Forebay Elevation	*Flood Gate Discharge c.f.s.*	*Regulating Gate Discharge c.f.s.*	*Total c.f.s.*
230	180,000	4,000	184,000
242 (normal)	345,000	14,700	359,700
247 (extreme high)	410,000	20,000	430,000

water if more than one opening should be in use along the collecting gallery.

The fish hoist consists of a cage which is pulled up an inclined trackway. The cage is 10 ft. square at the bottom with a sloping front end. (Fig. 6). The sides are wire mesh except at the bottom where plates extend up one foot to form a watertight compartment. A door on one side is automatically raised before the cage starts its upward trip. The cage is tipped on arrival at the upper level to pour the water and collected fish into the forebay.

In the down position the cage rests in a water filled basin with intake located so that the current attracts the fish into the cage. A wire mesh gate at the entrance closes with the door of the cage so that, when the cage is raised, the fish cannot pass into the basin. The gate opens when the cage returns.

The hoist was satisfactorily put into operation in August 1957; in ninety days, 1,127 fish passed over the dam. Operation can be automatic on a timed cycle, but at present the cage is controlled manually.

Logging

Both pulpwood and sawlogs must be passed over the dam at Beechwood. However, the characteristics of the river are such that the drives take place at the ebb of the flood. Hence no log chute is provided, the logs being passed over the open spillways or flushed through a regulating gate. Directing booms are stretched in the forebay and attached to anchors embedded in the piers.

Powerhouse (Fig. 7)

The powerhouse is an integral design; i.e., intake and powerhouse are combined. In this case the downstream wall of the intake constitutes the upstream wall of the generator room.

The units have concrete semi-spiral cases fed by a three-gate water passage. Trash racks are placed in the entrance and head gates, each with its own hoist, just downstream. The emergency gates, of which there is only one set, are dropped in the trash rack gains during repairs. The head gates can be removed by bringing them to the upstream face of the gate slot and transferring the lift from gate hoist to gantry.

The powerhouse has settings for three units, of which only two are installed initially. Since the unit spacing is 70 feet, it was possible to place the office and control buildings on the transformer deck between transformers, resulting in a very compact arrangement. Entrance to both buildings is reached from a balcony at elev. 218, 12 ft. above the generator room floor.

The superstructure is steel-framed with reinforced concrete walls. The walls of the powerhouse are 10 in. thick; those of the office and control building are 8 in. thick. All are poured with no expansion joints, and experience to date has revealed only a few hair-line cracks on the lines of the columns.

The large size of the units necessitates large generator room volumes. When the coldest part of the winter is reached, the available flow is low and hence the units will be operated at reduced loads. Calculations showed that it would not be possible to heat the space with heat from the units. Electrical heat was added, minimized by using light-weight pre-cast roof slabs of high insulating value. On this a bonded roof was laid.

The east end of the powerhouse consists chiefly of the retaining wall against which the east cut-off dam abuts. The main entrance is also at the east end of the downstream wall, the approach being just inside the retaining wall. The entrance opens directly on the repair bay.

East Cut-off Wall

Figure 8 shows the section of the earth fill dam which forms the cut-off. The compacted clay core and pervious blankets are of local material. As the core approaches the powerhouse retaining wall, it is widened out to increase the length of the leakage path along the concrete face. The blanket material is so pervious that toe drains are not necessary.

Compaction was done in 6-in. layers using a sheepsfoot roller. The rock foundations were grouted and smoothed with concrete for deposit of the core.

The roadway to the intake extends along the top of the dam, which is covered by a 3-ft. layer of gravel. The upstream slope is covered with 3 ft. of rip-rap and the downstream slope with 1 ft. of coarse gravel.

Powerhouse Auxiliaries

The powerhouse crane has a capacity of 175 tons on the main hook and 25 tons on the auxiliary hook. It is a conventional overhead travelling type with the operating cab at the upstream end of the bridge.

The gates, racks, and emergency gates are serviced by a 60-ton gantry crane on the intake. This gantry has unequal legs, the upstream legs being supported by tracks at deck level while the downstream tracks run on rails laid at the level of the gatehouse roof.

Provision has been made to move the transformers inside the powerhouse using a fixed hoist located over the roadway at the powerhouse entrance. The transformer is run out on a rail car, slung, and lifted by the

Fig. 6. Fish skip being raised to forebay.

hoist. The rail car is then run to one side and the transformer lowered to tracks provided at the repair bay level.

The various service auxiliaries in the powerhouse consist of strained water supply, fire pump, governor oil and air pressure systems, general service air, circuit breaker air pressure supply, oil filtering system, etc.

The portable oil filter used for filtering the transformer insulating oil is mounted on a four-wheel trailer suitable for towing on the highway. This unit includes a heater for heating the incoming oil to 80°C., a filter for removing solid matter, and a vacuum chamber for drying and de-aerating the oil. The unit has a capacity of 450 I.g.p.m. and requires 64 kw. for operation. Although this filter was supplied as part of the equipment for Beechwood it may be used readily for other transformers on the N.B.E.P.C. system.

General service air is provided by a portable electrically-driven compressor with a capacity of 160 c.f.m. free air at 100 p.s.i. Electrical outlets are provided at intervals around powerhouse and intake so that the installation of piping runs has been avoided.

Turbines

The turbines of this development are described elsewhere.* They are the Kaplan type rated at 45,000 h.p. at a net head of 57 feet and 109.1 r.p.m. At the time of installation, these were the largest of their kind manufactured and installed in Canada.

Single Line Station Diagram

Figure 9 shows the single line diagram for the generating station and high voltage switching stations. Power is generated at 13.8 kv. and is transformed to 138 kv. through the unit transformers. It will be noted that high voltage switching only is provided. There are no low voltage circuit breakers between the generators and the unit transformers. Transmission line No. 103 to Fredericton is connected to the 138 kv. bus. A tie transformer has been installed between the 138 kv. and the 69 kv. buses, and three 69 kv. lines are connected to this 69 kv. bus.

The 138 kv. bus is sectionalized by means of a disconnecting switch. In order to make full use of these two bus sections at this stage of development, the second unit has been connected temporarily in place of the third unit. On the 138 kv. Fredericton line No. 103, a bypass switch has been installed around the line circuit breaker to provide for breaker maintenance. On the 69kv. Fredericton and Tobique lines, No. 20 and 37 respectively, a line paralleling switch has been installed to permit maintenance of either of these line breakers with the other breaker in service.

A manually-operated disconnect switch has been provided in the low voltage bus between each generator and unit transformer to permit isolation of the generator for testing and maintenance. Power for station service is taken from units 1 and 2 to separate station service transformers through 13.8 kv. disconnect switches.

System Diagram

Figure 10 shows the connection of the Beechwood generating station into the New Brunswick Electric Power Commission transmission system. The 138 kv. line to Fredericton continues on to the Grand Lake generating station and Moncton. The 69 kv. lines No. 20 and 37 connect into the existing 69 kv. transmission lines between Fredericton and the Tobique Narrows generating station. The 69 kv. line No. 55 extends to the Canadian border to form an interconnection with the Maine Public Service Company.

Main Power Apparatus

Each totally-enclosed water-cooled generator is rated 40,000 kva., 0.90 power factor, 13.8 kv., 109.1 r.p.m. The stator coil insulation is Class "B", with the major insulation of asphalt-bonded mica tape. The field poles are provided with non-continuous amortisseur windings. The generators are of overhung design; i.e., the combined thrust and lower guide bearing is installed below the rotor, and there is no upper guide bearing.

Each three-phase unit power transformer is rated 40,000 k.v.a., 13.8-138 kv., Type OFW, 60°C. temperature rise. The transformers are connected low-voltage delta and high-voltage star with solidly grounded neutral. Full capacity off-load taps are provided at 141.45, 144.9, 148.35 and 151.8 kv. on the high voltage windings. Two separate oil-to-water heat exchangers are provided for each transformer. Each heat exchanger is capable of dissipating 80% of the transformer losses at full load with a maximum cooling water temperature of 20°C.

The three-phase tie transformer between the 138 kv. and 69 kv. buses in the switching station is rated 22,500/30,000 kva., Type ONS ONP, 55°C. rise, connected star-star with solidly grounded neutrals, and is provided with a 12.47 kv. delta-connected tertiary winding. This tertiary winding is not used at present, and one corner of the delta is grounded externally. This transformer is provided with on-load tapchanging gear having a range of ± 10% on the 138 kv. windings.

The 138 kv. windings of these transformers are designed with full 650 kv. impulse withstand level. This level was chosen due to operating conditions; voltages as high as 155 kv. may be experienced at the sending end of the 138 kv. system. Lightning arresters with a maximum line-to-ground voltage of 145 kv. rms are provided at each transformer.

The indoor sections of the 13.8 kv. buses between the generator and transformers are rated 2500 amp. and were fabricated on the job. The outdoor sections of this buswork to the transformers were factory-assembled with the three phases housed in one circular enclosure. This section includes a baffle with bushings to form a seal to prevent condensation of moisture in the outdoor section. The impulse withstand level of all sections of the low voltage bus is 110 kv.

The 138 kv. circuit breakers are three-pole, high-speed, air-blast breakers, rated 800 amp., with a symmetrical interrupting capacity of 2500 Mva., and a total interrupting time of 3.5 cycles. The 69 kv. circuit breakers are also air blast breakers and are rated 800 amp., 1000 Mva., 3.5 cycles. Separately mounted 138 kv. and 69 kv. oil-filled current transformers are installed on the line and transformer sides of these circuit breakers. The impulse withstand level of the 138 kv. bus, circuit breakers and current transformers is 650 kv.

Station Service Distribution

Power for station service is distributed at 575 volts. Each of the two station service transformers is rated 750 kva., 13.8 kv.-575 volts, Type ONS, 55°C. rise, three-phase, connected delta-delta, and is provided with off-load voltage taps only. These transformers are installed outdoors on the downstream deck of the powerhouse with the unit power transformers. These transformers are connected to the 13.8 kv. generator buses through disconnecting switches which are capable of breaking the transformer magnetizing current.

The main station service switchboard is of self-supporting, totally-

*Beechwood Kaplan Turbines: Hydraulic and Mechanical Features. L. M. Boyd and W. S. McIlquham. The Engineering Journal, 1959, Feb., p. 56.

enclosed, dead-front construction, and is installed at one end of the low voltage bus tunnel. Air circuit breakers are used throughout for 575-volt power distribution and for starting the 125 h.p. governor oil pumps. Duplicate radial feeders are provided from the main station service switchboard to sub-distribution switchboards located at each generating unit, and in the gatehouse, service bay, and switching station. A separate sub-distribution switchboard is provided in the powerhouse at each generating unit, and each 70-ft. generator bay is supplied with auxiliary power for motors and lighting on a unit basis. Interlocks are provided throughout the station service power distribution system to prevent parallelling of the two main power sources. Single-phase dry type distribution transformers, with 115/230 volt secondaries, are installed for the power supply for lighting, heating and fractional horsepower motors as required in each of the sub-distribution areas.

The total connected load on the station service distribution system is approximately 3,360 kva. Normally, this load is split and supplied from the two station service transformers. In times of emergency this load may be supplied from one transformer only, and demand ammeters have been provided to enable the transformer loading to be regulated.

Control, Metering, and Relaying Equipment

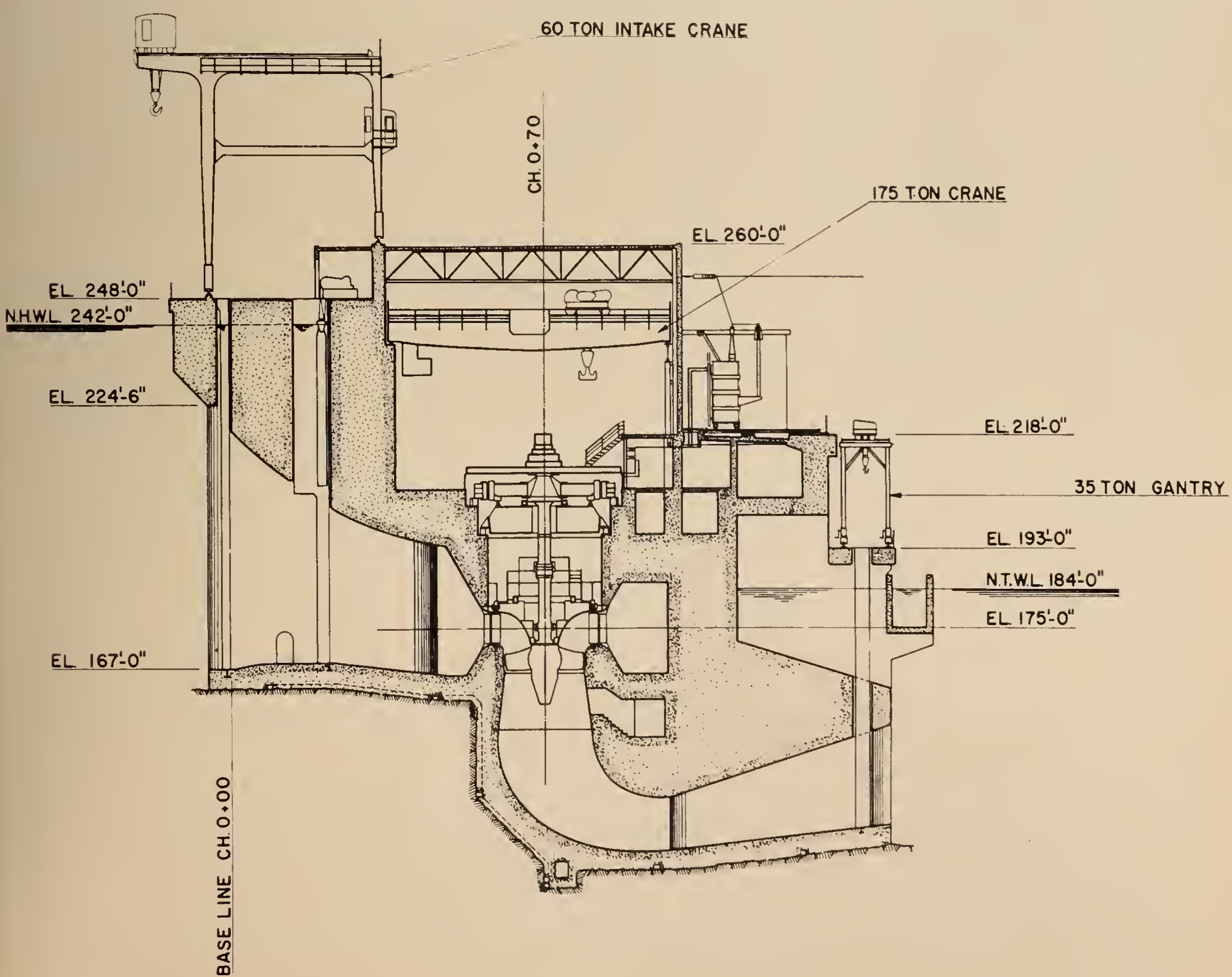
The control equipment is located in two general areas in the powerhouse. The main control, metering, and relay equipment is in the control room on the downstream side of the powerhouse, and the apparatus for generator and turbine control is on the generator room floor.

The control circuitry has been designed so that this station may be operated by a minimum staff. Consequently, all normal operating functions concerning the starting, stopping, and loading of the generators may be performed from the control room by the operator.

In general, all devices and indicating instruments required for the control of generation, synchronizing, and line switching are located on the benchboard in the control room. Two duplex switchboards are provided in the control room. The front panels of these duplex boards contain control equipment and instrumentation not directly associated with the control of generation or the transmission system. The rear panels contain the protective relay equipment for the generators, transformers, and transmission lines. The operator's desk in the control room contains a keyboard for the communication system, switches for the powerhouse signal system, and the station load and frequency control equipment associated with the electro-hydraulic governors.

A generator field cubicle consisting of four cells is provided for each generator and located on the generator room floor. Three of the cells contain the generator and main exciter field circuit breakers, the automatic voltage regulator with its rheostat in the main exciter field circuit, the generator and

Fig. 7. Typical section of powerhouse.



turbine bearing thermometers, and miscellaneous electrical equipment for the turbine and generator control circuits. One cell contains relays and auxiliary devices for the electro-hydraulic governor. Automatic braking has been provided for stopping the units as part of the automatic shutdown sequence.

It is not the purpose of this paper to give a detailed description of all the various features of the control and protective circuits in the powerhouse and switching station, but certain features of more than passing interest are described in some detail.*

Electro-Hydraulic Governors

The turbines for this development are provided with electro-hydraulic governors. Wicket gates and turbine blades are controlled by a hydraulic system which receives its signal from a frequency-sensitive electrical network rather than from a speed-sensitive mechanical element. Briefly, the voltage from the permanent-magnet generator mounted on the generator shaft is fed into a resistance-capacitance circuit which is resonant at system frequency (60 cycles per second). Any deviation above or below normal frequency is thus detected; a raise or lower signal is given to electronic tubes, which in turn power the electrically-operated control valve of the hydraulic servo-system. The actual circuitry of these electro-hydraulic governors incorporates a large number of auxiliary control and protective devices. The disposition of the various components is as follows.

The regulator cubicle, which forms one cell of the field cubicle on the generator room floor, contains the following equipment: the electronic regulator, including the power tubes; relays for protective features, gate locking and gate limiting control; frequency relays; relays for the selection of the damping; rheostat for the speed droop setting; rheostat for the speed-no-load gate setting.

The actuator cabinet on the generator room floor contains the electro-hydraulic control valve which provides the link between the electrical and mechanical systems. The actuator cabinet also contains the following auxiliary equipment: gate position potentiometers; gate limit control mechanism and indicator; gate lock mechanism controls and indicator; electrical tachometer; gate position indicator; start-stop pushbuttons.

*A complete tabulation of protective and alarm functions for generators, transformers, transmission lines, and auxiliary equipment in the station was given with the original paper. A copy of this (Fig. 12) may be obtained from the editor of the Journal.

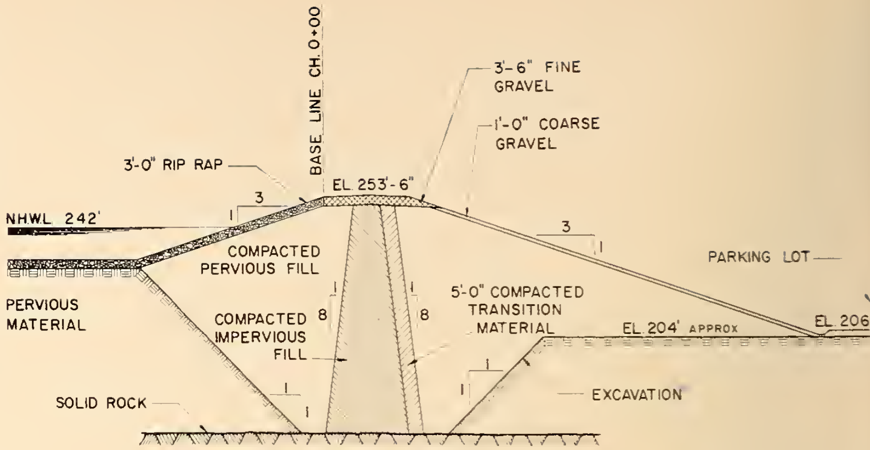


Fig. 8. Typical section of earth dam.

The controls for each governor which may be required by the station operator during normal operation are located in the control room on the benchboard, duplex board, or on the operator's desk. These controls are grouped as follows:

On the benchboard: calibrated rheostat for the power setting for the unit when on individual operation; calibrated rheostat for the frequency setting for the unit when on individual operation; selector switch to adjust the service damping; switches for the control of the gate limit and actuator lock; stop button for complete load rejection; indicating instruments for gate position, gate limit position and tachometer.

On one panel of the duplex board: selector switch and indicator for either individual or joint operation whereby the unit may be operated independently or on station control; selector switch and indicator for the selection of either no load or service damping; balance instrument for the regulating network.

On the operator's desk: All generators in the station may be operated on a station basis, that is, joint operation. The three rheostats required for joint operation are located on the operator's desk and are as follows: a calibrated rheostat for the power setting for the station; a calibrated rheostat for the frequency setting for the system; a calibrated rheostat for the regulating capacity, i.e., station droop characteristics.

Electro-hydraulic governors were selected for this installation only after considerable thought had been given to the requirements for load and frequency control on The New Brunswick Electric Power Commission system. At present, the two units at Beechwood represent approximately 23% of the total generation of the N.B.E.P.C. system with its interconnections. The choice of electro-hydraulic governors was based on the ease with which the operating characteristics of the governors may be adjusted to meet the daily and seasonal requirements for regulation. For each individual governor, the separate adjustment of the speed droop and damping ensures that the proper response may be obtained. Joint operation is readily provided by electrical interconnection of the individual governors within the station and gives a simple and effective control of all units in service. On joint operation, the total power output, frequency, and regulating characteristic for the whole station are easily adjusted with one set of controls, and the units will share the load at all times, even when operated isochronously, that is, with zero speed droop on flat frequency control. It is hoped that these two units, equipped with electro-hydraulic governors, will assist considerably in maintaining system frequency closely without the installation of additional frequency control equipment.

Supervisory Control of the Tobique Narrows Generating Station

The second item of interest is that supervisory control equipment has been installed at Beechwood to exercise remote control of the Tobique Narrows generating station some 17 miles upstream. This supervisory control and telemetering equipment together with the associated power line carrier equipment, was installed prior to the on-power date for the first unit at Beechwood. This enabled The New Brunswick Electric Power Commission to staff the Beechwood generating station with the operators from Tobique.

The supervisory control equipment is installed in the control room at

Beechwood and forms two front panels of one of the duplex switchboards. This supervisory control equipment contains a total of 24 points and gives the operator at Beechwood complete remote control of the Tobique station with its two generators and two 69 kv. transmission lines as follows:

Start and stop each of the two generators (which are provided with automatic synchronizing and speed matching); control the kw. loading on each generator; control and position indication for each of the line circuit breakers; receive alarm indications of abnormal conditions in the Tobique station; raise and lower the Tobique regulating gate.

In addition, "as-called-for" telemetering is provided to give the operator at Beechwood the following instrument readings from Tobique: generator volts; generator kw. and kvar. loadings; turbine gate and load limit positions; headwater and tailwater levels; 69 kv. bus volts.

Continuous telemetering of the Tobique total kw. output is provided at Beechwood, together with an integration of this reading, to give the total kilowatt-hours generated. The equipment at Beechwood also includes a device for retransmission of the Tobique kw. generation to the system dispatch office in Fredericton.

Communication System

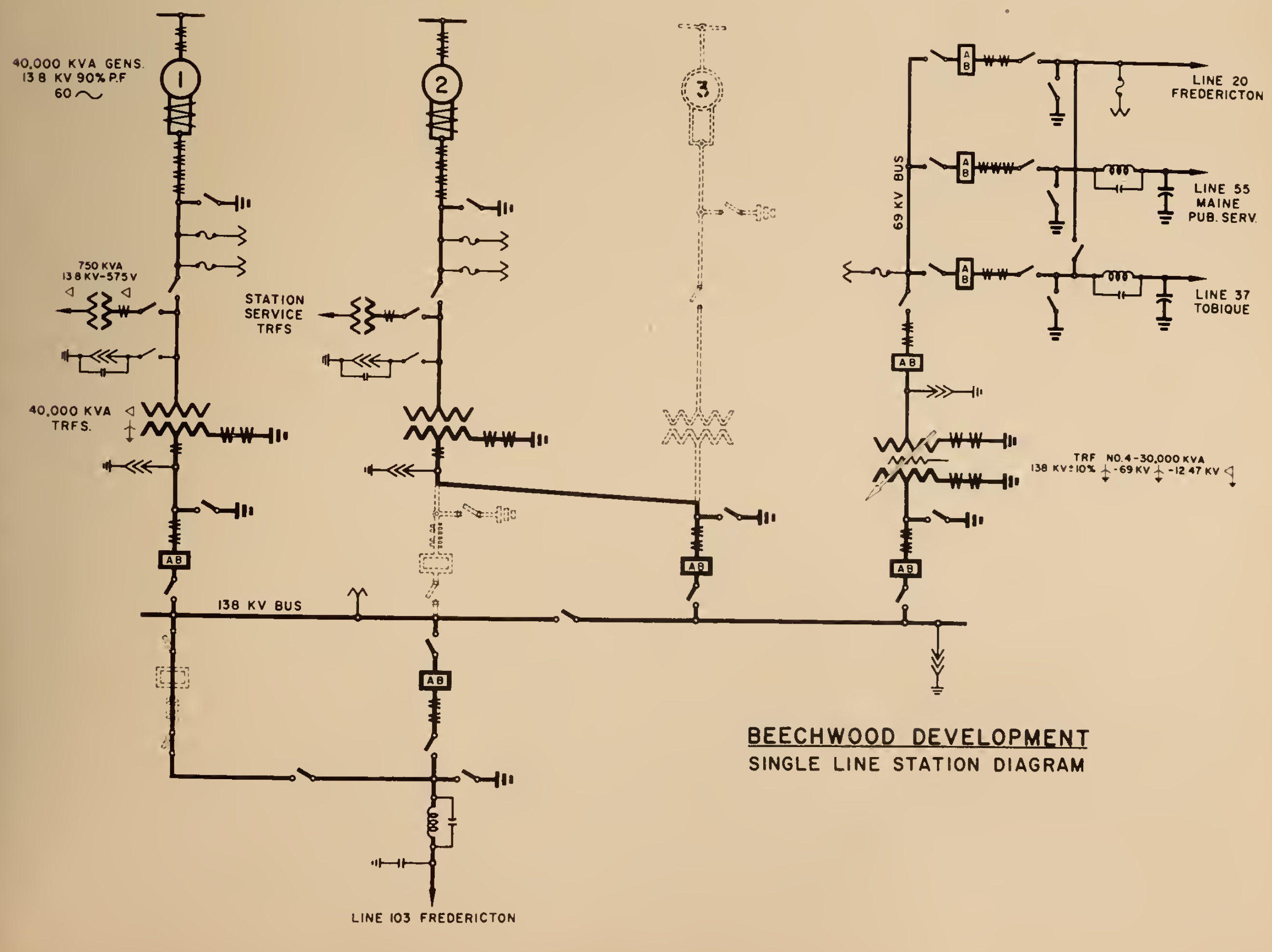
The third item, of interest to power utility engineers, concerns the N.B.E.P.C. communication system, of which Beechwood is the hub for the Upper St. John River Valley. Prior to the system expansion in the years 1956-58, of which the construction of Beechwood was a part, the N.B.E.P.C. relied on commercial telephone service between the various points on their system, except for some mobile F/M radio installations. After considerable study, which included the system expansion for possibly the next 25 years, it was recommended that the N.B.E.P.C. install and operate their own private communication system.

The recommended system utilizes power line carrier for all major links between stations, and is required to provide the following facilities: duplex voice channels for load dispatching, system operation and distribution operational traffic; continuous telemetering; supervisory control; relay protection.

The mobile F/M system is used for local distribution traffic during normal periods, and as an emergency standby to the carrier system when necessary. The commercial telephone system is not regarded as a back-up service to the privately owned carrier system. During severe storms the land lines are considered to be more subject to outages due to mechanical failue than are the power system transmission lines. Delays caused by prior calls on the commercial system could be a factor affecting the restoration of service on the power system in times of trouble.

It will be realized that a large number of carrier frequencies will ultimately be required for such a communication system. In order to accommodate all of the functions required for present and future use, single sideband carrier was selected for this application after considerable study. This choice was based on the need to conserve the number of frequencies required in the 50-200 kc. band, and to avoid interference with

Fig. 9. Single line diagram.



existing carrier installations at present operated by others in the Maritime area.

This communication system is basically a number of radial links emanating from the Fredericton dispatch office. The radial system was chosen as it offered the following advantages: the concentration of approximately one-half of the carrier sets at Fredericton localizes the maintenance to a considerable extent; a point-to-point conversion does not tie up intermediate carrier links unnecessarily; a high degree of privacy is obtained; a great degree of flexibility is obtained which permits future changes both as to frequencies and equipment in the communication network; as new links are established, they may be commissioned without interfering unduly with the carrier sets previously installed.

At both Fredericton and Beechwood, automatic dialling and PAX equipment is installed for all traffic in any direction so that the station operator in the control room is not required to perform the duties of a telephone operator. Fully automatic dialling is possible between all points on the system. A priority circuit is provided to enable the operator to take precedence over all calls and to cut into existing calls at will.

The Beechwood Generating Station is a secondary hub for this communication system for the Upper St. John River Valley. At Beechwood at the present time there are three radial carrier links installed as follows:

Beechwood/Fredericton. This carrier installation provides duplex voice communication and continuous kw. telemetering of both the Beechwood and Tobique outputs.

Beechwood/Tobique. Provides duplex communication supervisory control of the Tobique Station from Beechwood, and continuous kw. telemetering of the Tobique output.

Beechwood/Maine Public Service Company. Provides duplex communication and line relay protection.

All carrier circuits operate with phase-to-ground coupling on the transmission line. Many of the coupling capacitors are supplied with potential devices for synchronizing and metering.

All single sideband equipment is of the "reduced carrier" type operating with magnetostrictive oscillators. The equipment has a maximum output of 20 watts for the transmitter upper sideband and 0.8 watt for the carrier.

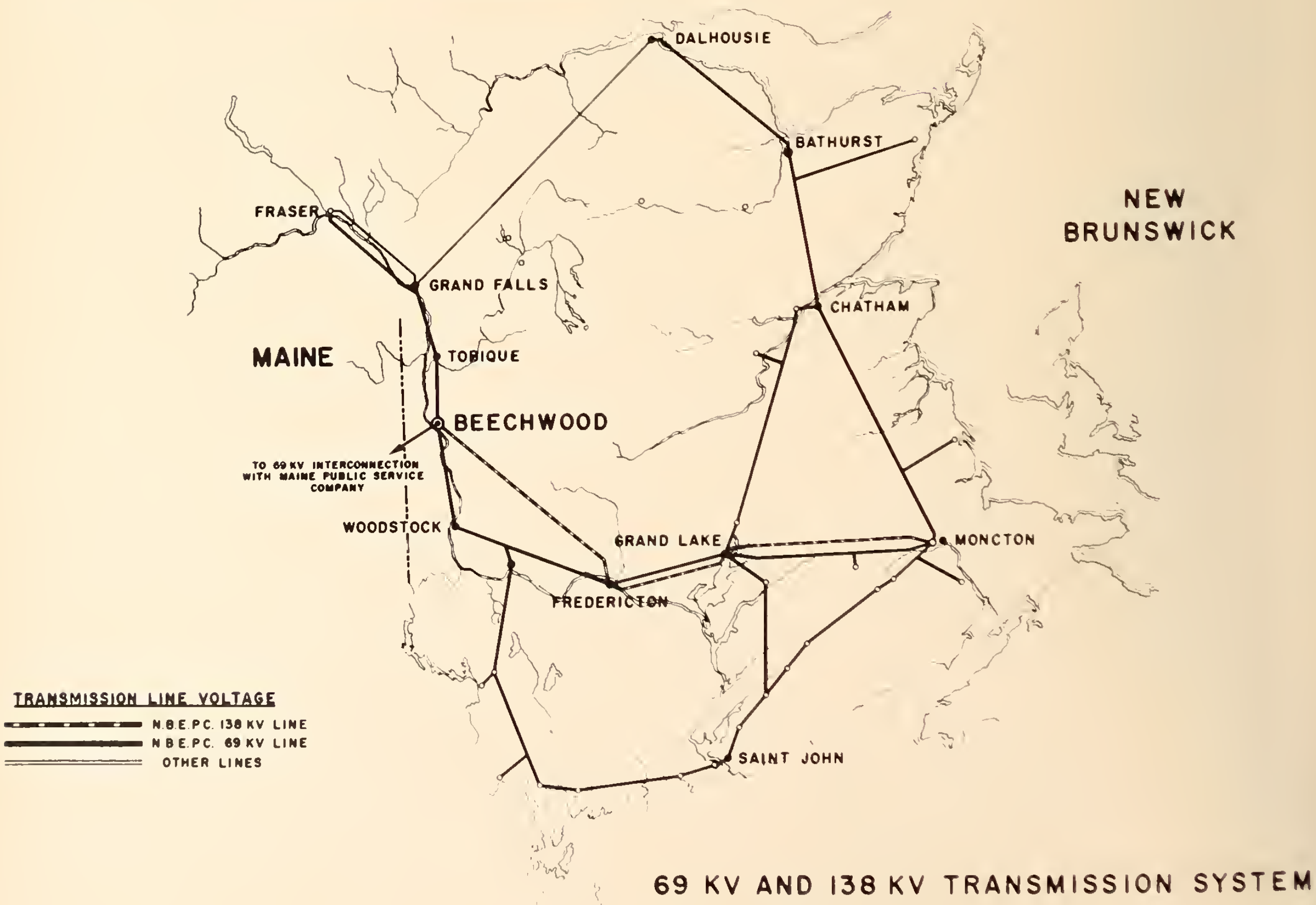
Draft Tube Evacuation and Spinning Reserve

The fourth item of interest is the provision for the evacuation of the water in the draft tube for the automatic "motoring-generating" changeover scheme.

In principle, this scheme has been provided so that either unit, when not required for kw. generation, may be operated as a synchronous condenser with an automatic spinning reserve feature. The unit will revert to generator operation automatically when required by system frequency conditions.

To explain this operation, assume that a unit is operating as a generator. To change over to synchronous condenser operation, the operator in the control room must first close the turbine gates, using the manual control switch. The operator then moves a selector switch to the "motoring" position. Two solenoid-operated valves, size 6 in. and 2 in. respectively, then open and introduce compressed air

Fig. 10. 138 kv. transmission system.



into the draft tube to depress the tailwater to a level below the runner blades. At this point the 6 in. valve closes. The 2 in. valve remains in the circuit to regulate the water level and admits additional air to make up any air leakage. The unit is now connected to the system, is running as a synchronous condenser, and may be used to supply reactive power if required. Should a sustained drop in system frequency occur to approximately 59.5 cycles for some three seconds (adjustable within the range of 1-5 seconds) indicating a deficiency of generation on the system, then a signal is given to the electro-hydraulic governor which opens the turbine gates fully. The air in the draft tube is carried out by the incoming water, and the full out-put of the generator is made available to the system in some few seconds. Upon restoration of system frequency to 60 cycles, normal governor action takes over and regulates the unit loading and frequency automatically.

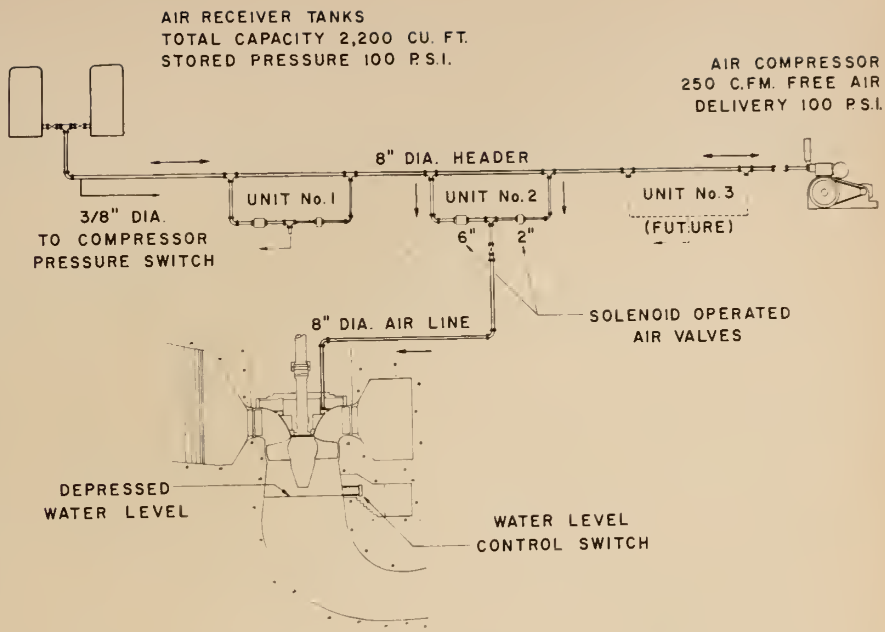


Fig. 11. Schematic diagram, piping and valves draft tube water depression system.

With this scheme a unit cannot be motored until the compressed air storage tank is fully charged, which requires approximately one hour. If the compressed air in the storage tank is insufficient to depress the draft tube level fully, a pressure switch on the tank actuates a "do not motor" warning in the control room.

The schematic diagram of the piping and valve arrangement for the draft tube water depression system is shown in Fig 11. The system is supplied by a 250 c.f.m. compressor discharging at 100 p.s.i. Air storage is provided by two receivers with a total volume of 2200 cubic feet. The volume stored at 100 p.s.i., when expanded to the draft tube pressure of approximately 12 p.s.i., is 20% greater than that required to depress the draft tube water level clear of the runner. This additional capacity is required to compensate for any loss of air due to leakage or due to the churning action of the blades during the initial blowdown.

The units are served by an 8 in. diameter header which runs the length of the station in the piping gallery. The air is discharged at each unit through the 6 in. and 2 in. quick-opening solenoid-operated air valves referred to previously. The air is passed from the valves through an 8 in. airline to the turbine head cover, through which it is admitted to the draft tube. These solenoid-operated valves for each unit are controlled by a water level switch attached to the draft tube liner adjacent to the draft tube access door. This switch contains four electrodes set at elevations 156 ft. 2 in., 156 ft. 6 in., 156 ft. 9 in. and 157 ft. 0 in. When the water level is depressed to elevation 156 ft. 6 in., the 6 in. valve closes and air continues to be supplied through the 2 in. valve, which is controlled in the "close" and "open" positions by the electrodes at elevation 156 ft. 2 in. and 156 ft. 9 in. respectively. The lowest part of the runner hub is at elevation 158 ft. 3 in. The electrode at elevation 157 ft. 0 in. is used for alarm purposes. The time required to depress the water level in the draft tube is a little less than one minute.

Protective Relaying

The protective relaying for the 138 kv. and 69 kv. transmission lines should also be mentioned as an item of interest. As noted previously under "Communication System", the construction of Beechwood was a part of the system expansion in the years 1956-58. During this period, the first 138 kv. transmission lines were placed in service between Beechwood, Grand Lake, and Moncton. In planning the protective relaying for this new high voltage transmission system, emphasis was placed on the need to standardize the protective relays for all new 138 kv. lines. In addition, it was necessary to equip many of the existing 69 kv. lines with new protective relays, as these lines would now operate in parallel with sections of the 138 kv. system. The same emphasis was placed on standardizing the protective relays for these 69 kv. lines. Extensive studies were made to determine the types of relays best suited to these applications. The types of relays thus selected, together with the basic relay circuitry, were then applied to all new 138 kv. lines and revisions to the 69 kv. lines on the N.B.E.P.C. system. Subsequent to this study, it was found necessary to depart slightly from these principles of standardization and utilize two types of distance relays, the selection of the relay type being dependent on the length of the line

Thus the 138 kv. line at Beechwood is provided with the following protective relaying: 3-stage directional reactance-measuring distance protection for phase-phase faults; 3-stage directional reactance-measuring distance protection for phase-ground faults; directional inverse-time overcurrent standby protection for phase-phase faults; directional inverse-time overcurrent standby protection for phase-ground faults.

Similarly, the three 69 kv. lines at Beechwood are provided with the following protective relay equipment: 3-stage directional reactance-measuring distance protection for phase-phase faults; directional inverse-time overcurrent protection for phase-ground faults; non-directional inverse-time overcurrent standby protection for phase-phase faults.

These relaying schemes were selected and specified for several reasons.

(continued on page 73)

BEECHWOOD KAPLAN TURBINES

Hydraulic and Mechanical Features

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L. M. Boyd, M.E.I.C., *Chief Engineer, Hydraulic Division,*

Dominion Engineering Company Limited

THE GENERATING equipment of the Beechwood development of the New Brunswick Power Commission consists of two vertical Kaplan turbines each rated at 45,000 h.p. under a net head of 57 feet at 109.1 r.p.m. Provision has been made for the addition of a third unit. These machines with a throat diameter of 18 ft. 4 in. are the largest Kaplan turbines in operation in Canada. They are also the first load responsive adjustable blade turbines to be designed and built by the authors' Company.

HYDRAULIC FEATURES

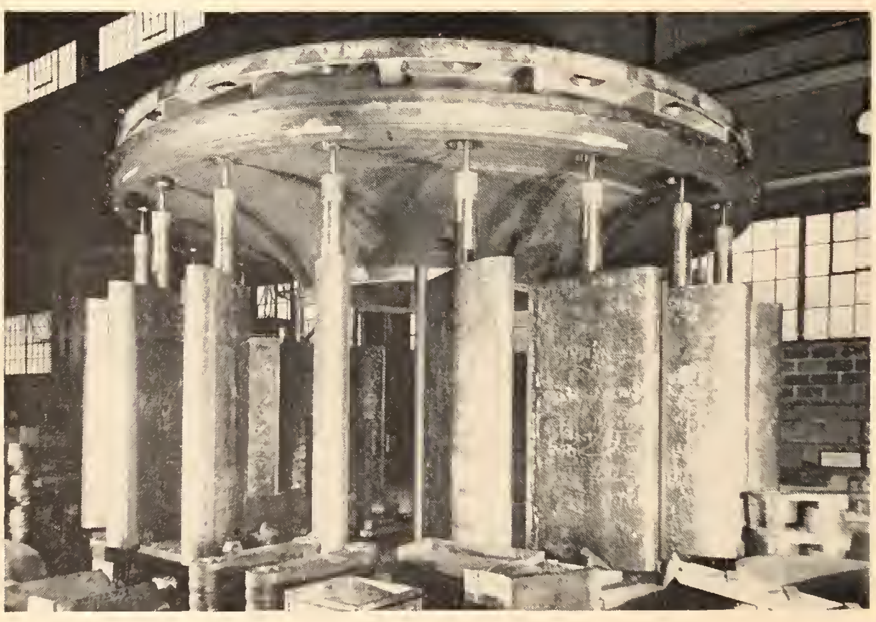
Model turbine equipment was tested in the hydraulic laboratory to determine the characteristics of the turbine to be manufactured for Beechwood. Several model runners and associated equipment were made and tested. The information obtained is presented in the form of curves plotted from the model tests.

Hydraulic Laboratory—Test Stand No. 1

Figure 1 shows model turbine test stand No. 1 with Kaplan type runner assembled.

In this open tank arrangement is installed a semi-volute case with a short intake section, a 10-vane stay ring, 20 wicket gates, elbow type draft tube and the model Kaplan runner designed for the Beechwood turbine. Under a head of 10 feet in the test stand, the performance characteristics of the model turbine are determined by measuring the discharge by means of a weir, the torque by means of a torque meter and the RPM by means of an electronic counter.

Lowering head cover into position on wicket gates



Characteristics of Kaplan Model Runner D-141-5

On the hill chart of Fig. 2 the performance characteristics of the model turbine, as determined by the tests carried out in test stand No. 1 (Fig. 1.) are consolidated and plotted.

On the abscissa is ϕ, the speed ratio, i.e.

$$\phi = \frac{\text{linear velocity at the throat diameter of the runner}}{\sqrt{2gh}}$$

and on the ordinate, HP_{11} (at best efficiency), i.e. unit horsepower or horsepower for a runner with a throat diameter of 1 foot operating under a head of 1 foot.

The model testing is done with a runner having a throat diameter of 16.326 in. and the HP_{11} values are calculated and plotted.

The rated horsepower for the Beechwood turbine is calculated from Fig. 2 as follows:

Rated horsepower

$$= HP_{11}\,(D)^2\,(H)^{3/2}$$
$$= 0.31\,(18.333)^2\,(57)^{3/2}$$
$$= 45{,}000 \text{ HP}$$

The test procedure is with the runner blades locked in the hub as a fixed blade runner, and several tests are required to obtain the performance as a Kaplan. In this instance six separate tests were run as indicated by the lines marked "A" = 0.50 to "A" = 3.00. This "A" dimension is a measure of the pitch or angle of the runner blades.

The lines for wicket gate angles and runner "A" dimension show these values to obtain best efficiency at the corresponding ϕ and HP_{11}.

Contours of best efficiency are plotted.

The Ns or specific speed lines are calculated by the formula $Ns = 153.2\phi \sqrt{HP_{11}}$ and are plotted as a ready reference.

Runaway Characteristics with Data for Beechwood

On the hill chart Fig. 3 are plotted the runaway speed characteristics of the model runner.

With the runner blade pitch or "A" dimension as the abscissa and the wicket gate angle as the ordinate, contours of runaway phi are plotted by the full lines. These contours show that the maximum runaway ϕ is obtained with the runner blades at 1.5 "A" dimension and approximately 49° wicket gate angle.

On the right hand side of this chart are tabulated data relating to Beechwood turbine operation.

(1) "Normal speed. ϕ versus H, turbine at 109.1 r.p.m." Here the effective heads and the corresponding ϕ values are tabulated for the turbine operating at the normal speed of 109.1 r.p.m.

Thus, in order to synchronize the turbine, the runner blades will be at the flat angle or at "A" dimension 0.50 and depending on the head the wicket gate angles required will be approximately 6° for 65 feet head and 11° for 35 feet head, at speed no load.

(2) "Runaway speed, turbine on cam, ϕ versus H". Here, for the effective heads tabulated, the corresponding ϕ values at runaway vary with the wicket gates and runner "A" dimension maintained on cam relation. This variation in the ϕ at runaway is shown by the broken lines.

The r.p.m. at runaway can be calculated by the ratio of the normal ϕ to the runaway ϕ. For Beechwood, the estimated maximum runaway speeds as calculated are as follows:

	Runaway Speed	
Head	*On Cam*	*Off Cam*
ft.	*r.p.m.*	*r.p.m.*
65	210	240
57	191	223

Hydraulic Torque on Runner Blades—Model

On the hill chart Fig. 4 are plotted the hydraulic torque characteristics on the blades of the model runner. In order to obtain the torque on the runner blades, special hydraulic controls and mechanical linkage were assembled in the runner hub. The required data were obtained from the tests by photographing instruments arranged on a panel, indicating: servomotor pressures, runner blade movement and wicket gate movement. With the runner blade "A" dimension as the abscissa and the wicket gate angle as the ordinate, contours of hydraulic torque are plotted at runaway ϕ for a head of one foot.

Zero torque indicates that the runner blades are in hydraulic balance.

The maximum torque tending to open the runner blades was obtained with the runner "A" dimension at 1.70 and the wicket gate angle of 50°.

Hydraulic Torque on Runner Blades — Beechwood

On Fig. 5 is shown the hydraulic torque on the runner blades of the Beechwood turbine under variation in head, for normal operation and at runaway, as calculated from the model test data.

(i) Normal operation on cam (109.1 r.p.m.). The variation in torque for the full range in power or runner "A" dimension is shown by the two full lines (1). At the design head of 57 feet the runner blades are very close to being in hydraulic balance for the full range in power.

(ii) Runaway operation *on* cam. The variation in torque for the full range of runner "A" dimension is shown by the two broken lines (2).

The magnitude of the hydraulic torque tending to open the runner blades under the rated head of 57 feet shows a maximum 12 times greater at runaway r.p.m. than at normal r.p.m.

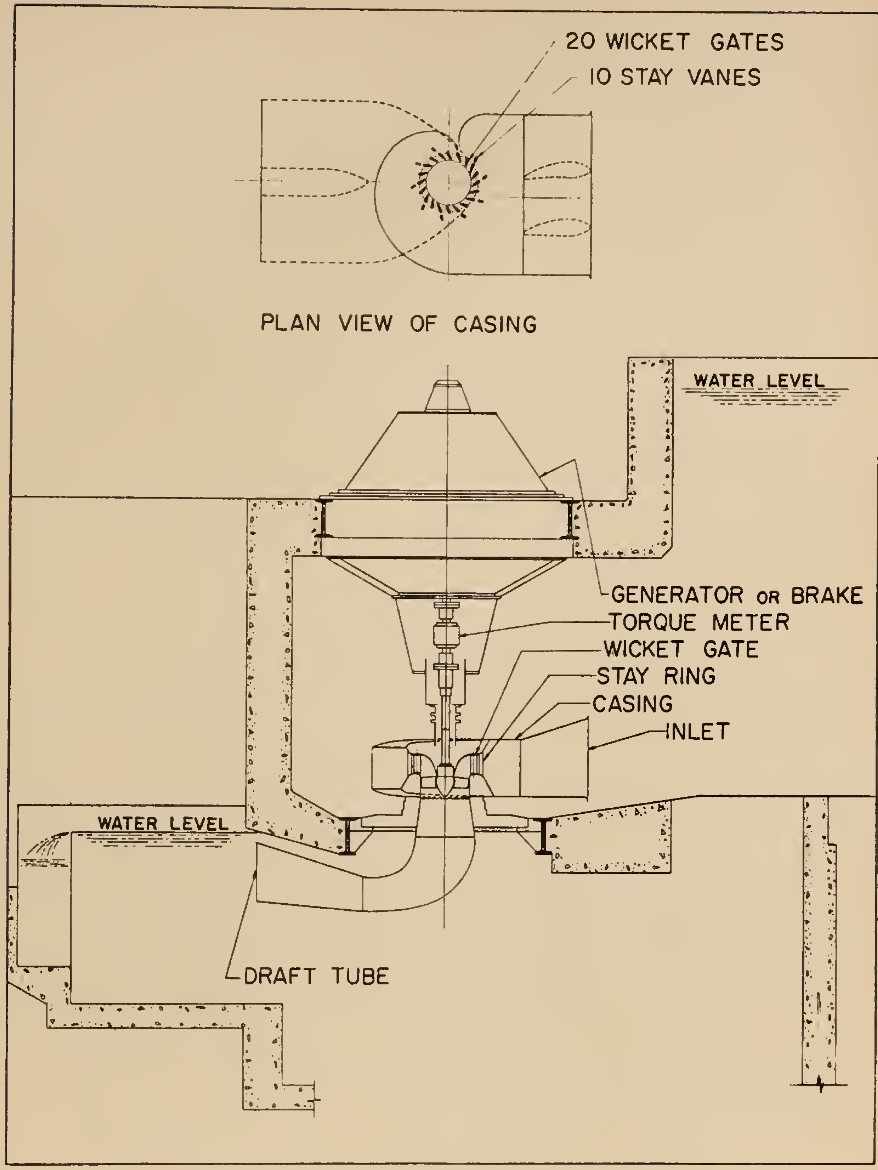


Fig. 1. Hydraulic laboratory—test stand no. 1.

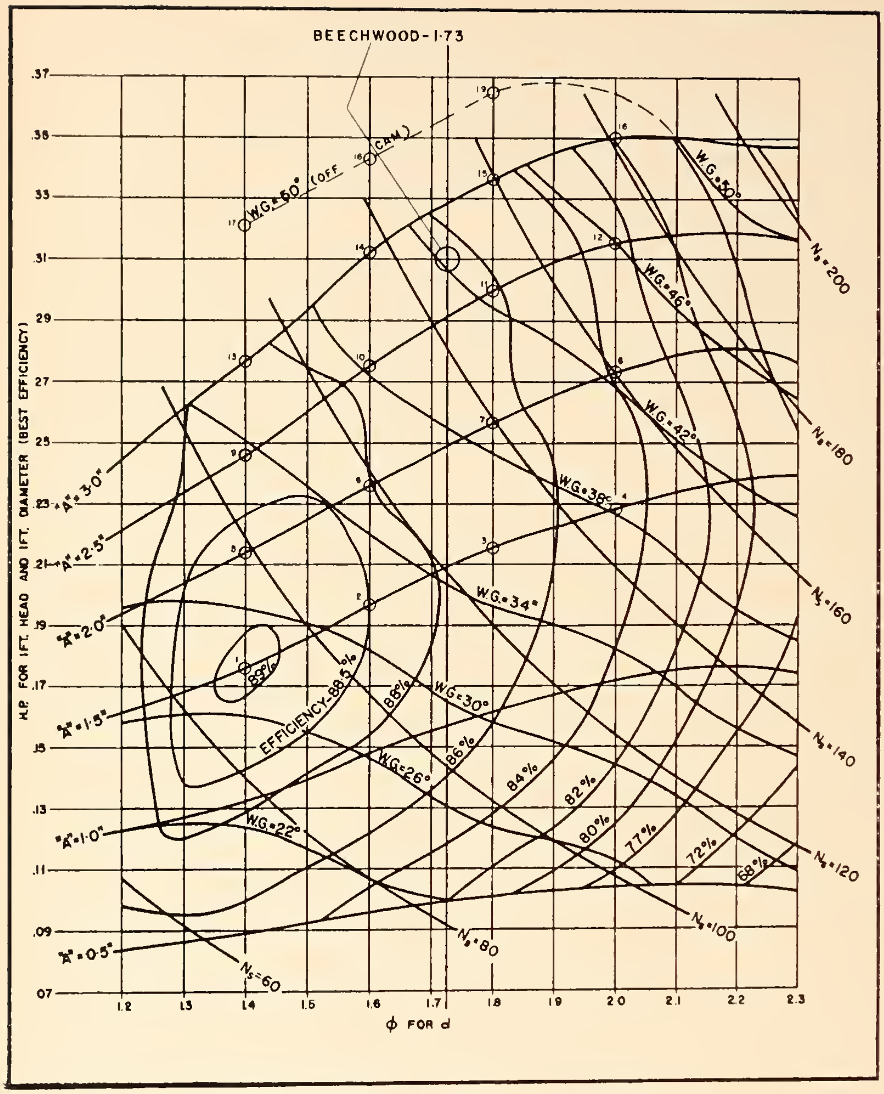


Fig. 2. Hill chart—model Kaplan runner.

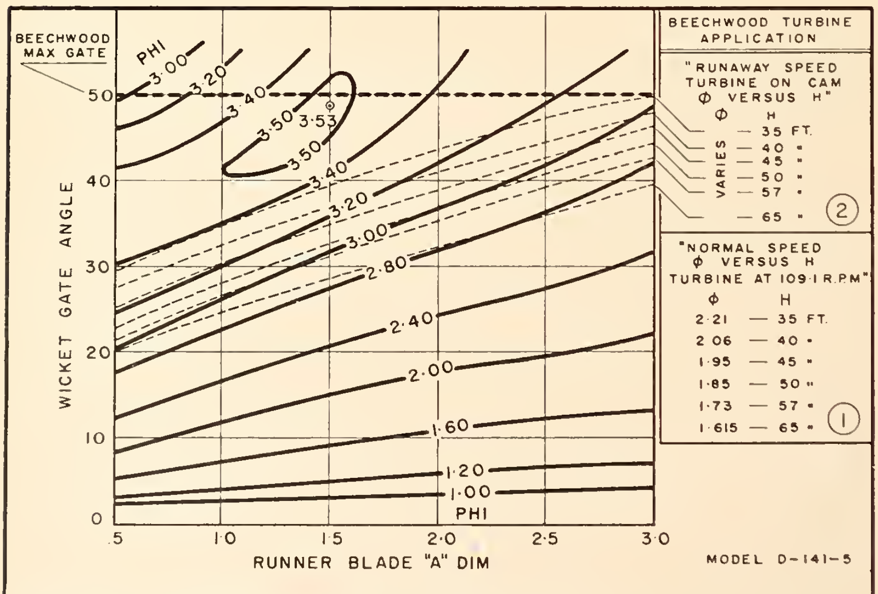


Fig. 3. Runaway speed ratio—model runner.

(iii) Runaway operation *off* cam. The maximum torque for full gate (50°) and the runner "A" dimension to produce maximum ϕ is shown by the top full line (3).

Beechwood Turbine Setting

Figure 6 shows the turbine setting; i.e., the elevation of the runner in relation to the tailwater elevation and the total head. The variation in the effective head as shown was estimated from the change in the tailwater elevation.

The sigma factors were calculated by the formula

$$\sigma = \frac{h_b - h_s - h_v}{H}$$

as detailed on Fig. 6. It will be noted that, for the turbine rating at 57 feet head the sigma factor is 0.8. This is based on the elevation of the runner axis 168.13 and the tailwater elevation at 180.7.

Sigma and Cavitation Characteristics of the Model Runner

In the cavitation laboratory the model runner was tested to obtain data showing:

(1) The sigma characteristics by measurements.

(2) The cavitation phenomena by photographs.

The photographs showed the model runner in operation over a sigma range from high values where no cavitation phenomena are visible to low values including that at the sigma break, i.e. the break in the $HP_{11} - \sigma$ curve, and beyond the break. The cavitation phenomenon showed clearly as it developed from incipient to a maximum with the change in sigma.

On the hill chart Fig. 2 the points (HP_{11} ϕ) at which the sigma and cavitation characteristics were tested, are identified by numbers (1 to 19). Points were selected to show the HP_{11}—σ curves, i.e. the change in HP_{11} with the change in σ.

Colour photographs were superimposed on the sigma curves to show the appearance of the runner in operation at the values of sigma indicated. The photographs were taken in colour to give better contrast and definition, and to facilitate the study of the cavitation phenomena and the effects of changes in blade design.

Beechwood Turbine—Estimated Performance

Figure 7 shows the estimated h.p. —efficiency curve at the rated head

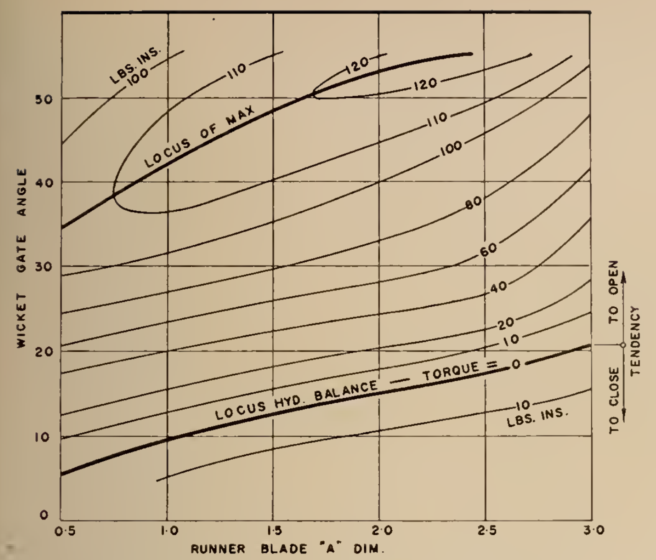


Fig. 4. Hydraulic torque on the blades of the model runner.

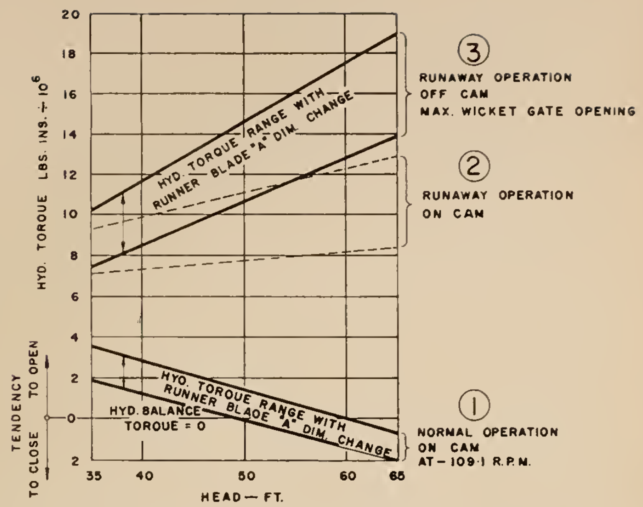


Fig. 5. Hydraulic torque on the runner blades estimated for Beechwood.

of 57 feet. Superimposed photographs showing the appearance of the model runner operating under equivalent field conditions of h.p., ϕ, and sigma, indicated the absence of visible cavitation phenomena for Beechwood operation.

Model Equivalents for Beechwood Turbine Performance

Figure 8 shows the model equivalents of HP_{11} and efficiency and the sigma curves which apply to the Beechwood turbine at rated head of 57 feet, i.e. $\phi = 1.73$. The sigma value at this head is 0.80.

MECHANICAL FEATURES

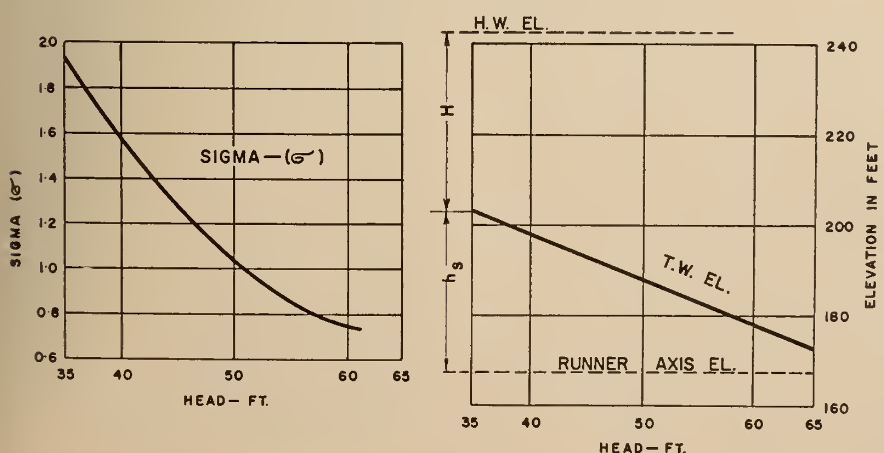
The mechanical design was largely conventional, with several minor departures. Throughout we drew heavily upon our experience with fixed blade turbines and manually controlled adjustable blade wheels.

Of particular interest are the selection and distribution of various materials throughout the machine. Steel castings, steel weldments, and iron castings all have their own merits and limitations. At the time of designing for Beechwood, all materials were becoming readily available. With our own steel and iron foundries, and with the extensive fabricating facilities of our associates to draw upon, our designers were not restricted. For each part the selection was based upon what were considered to be the most suitable inherent qualities. As will be seen, all three materials were freely used.

General Description

A concrete casing of the semi-spiral type leads the water from the upstream face of the power house to the turbine distributor. A concrete elbow type draft tube discharges the water into the tailrace.

Fig. 6. Beechwood turbine setting.



A cast steel stay ring of 7 ft. 4 in. distributor width with ten welded steel stay vanes carries the superimposed loads of the concrete, machinery, and hydraulic thrust, and directs the flow of water into the wicket gates. Twenty cast steel wicket gates control the speed of the unit.

The head cover is of cast iron in three main parts, the outer, inner and lower sections. The outer and inner sections are further sub-divided to facilitate manufacture and handling. The bottom ring is of cast steel and divided into sections.

Cast iron servomotors mounted in a fabricated steel pit liner operate the wicket gates through a conventional arrangement of links, levers, and a cast steel operating ring.

The throat ring is partly spherical in form, of pressed fabricated plate steel construction, machined in sections for handling. A cylindrical upper portion permits withdrawal of the runner. The spherical lower portion hugs the runner, minimizing leakage past the blade tips.

The draft tube liner is the simple conical type of fabricated steel extending 22 feet below the centreline of the turbine distributor.

The runner consists of five cast steel blades with integral trunnions mounted in a cast steel hub. Bronze bushed bearings carry the hydraulic and mechanical loads. A system of links and levers guided by a crosshead operates the blades under forces supplied by the blade servomotor mounted in an enlargement in the main shaft at the generator flange. The whole mechanism is flooded in a light oil topped up through the oil head. The runner is protected by a welded overlay of 18-8 stainless on the back of the blades in areas subject to cavitation and on the tips of the blades by a one-half inch stainless steel strip welded into position.

The shaft is of steel with integrally forged coupling flanges on each end including an enlargement at the generator end for the blade servo cylinder. An undercut enlargement near the lower flange provides a journal for the main bearing. Carbon segments, running on a stainless sleeve on the shaft, seal the head cover against leakage.

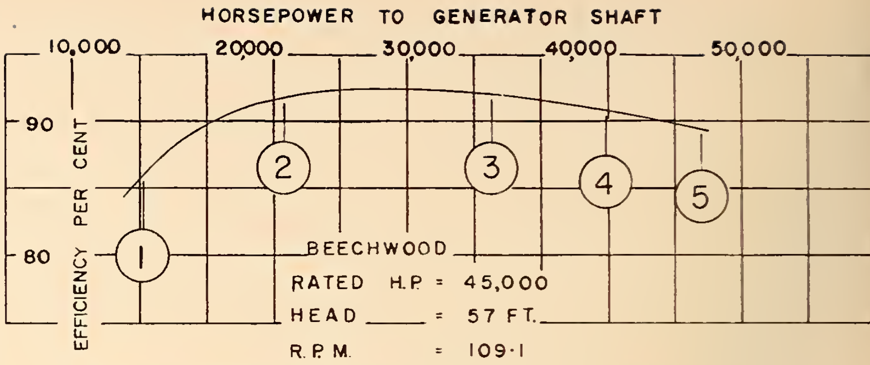


Fig. 7. Beechwood rating, HP-eff. curve HP_{11}-eff. and HP_{11} curves.

An oil bearing of the self-lubricated type with self-contained sump mounted in the lower head cover centralizes the wheel. A.C. and D.C. sump pumps protect the bearings against any water which leaks into the head cover past the shaft seals.

The oil head is mounted on the exciter frame above the generator. Oil from the governor is conducted through the governor oil piping and a system of stuffing boxes, and co-axially piped within the generator shaft to the blade servomotor. Movement of the blades is carried by means of a rod within the co-axial pipes in the generator shaft to the oil head where it is transmitted to the governor through a series of quadrants and cables. A small reservoir of oil at the top of the head maintains a static pressure on the oil in the runner hub.

Each unit is regulated by an electro-hydraulic governor. The gates are operated by the main servomotors in response to a speed-sensitive governor. The blades in turn are actuated by the blade servomotor, in response to movements of the wicket gates, through a cam in the actuator. The cam is three-dimensional, allowing manual adjustment of the cam action to suit seasonal changes in the effective head on the turbine.

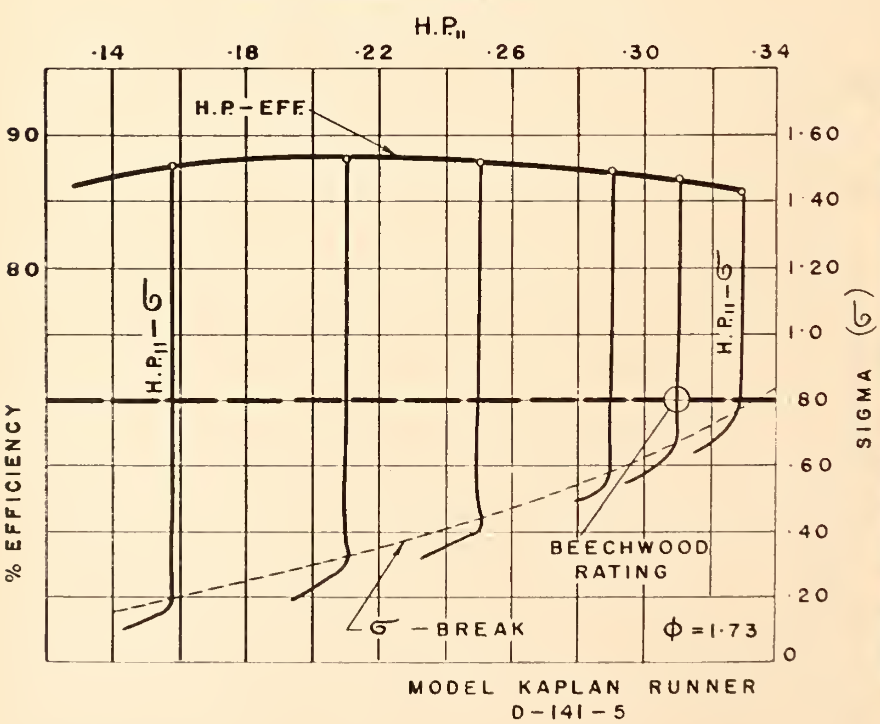
Unique Design Features

From the above description, the unit may be considered as rather conventional. However, several innovations were incorporated in the design.

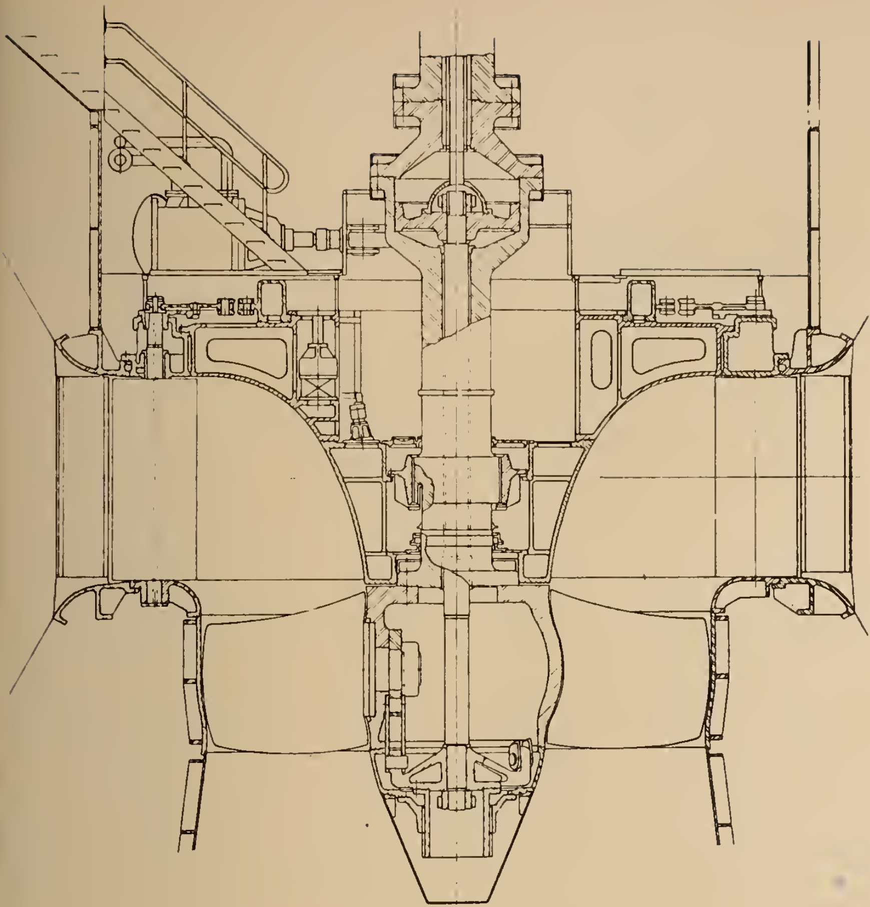
The crosshead in the runner hub, which prevents rotation of the spider under lateral forces of the levers and yet permits vertical motion in response to the blade servomotor, is a steel involute spline operating in a mating bronze guide. These splines were machine cut with conventional stock gear cutters. They provide an illustration of an application where advantage can be taken of the low cost and high precision inherent in gear cutting operations.

One of the most successful innovations was the design of the seals between the wheel blades and the hub. Kaplan wheels have long been plagued by leakage at this point. The problem is to keep the lubricant in the hub and water out by means of a packing which will not set up objectionable braking torque on the relatively large diameter of the blade trunnions. The problem is complicated by the fact that the packing is inac-

Fig. 8. Beechwood equivalents at rating.



Turning runner in shop after installation of blades



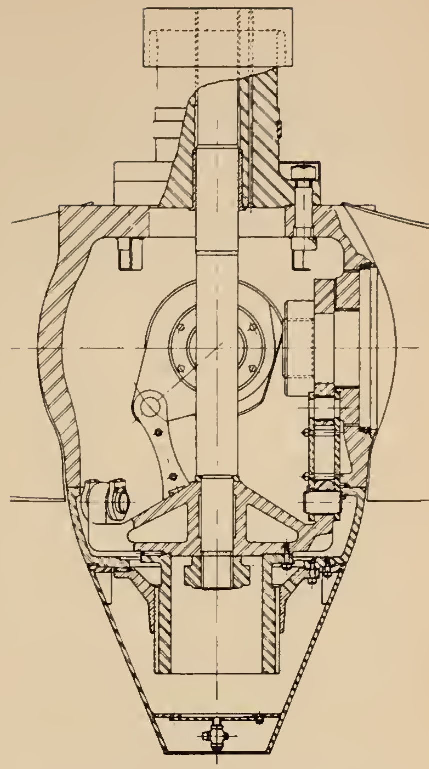


Fig. 9. Beechwood turbine — sectional elevation.

Fig. 10. Beechwood turbine hub section.

cessible and not easily adjustable. Furthermore, the design must permit replacement of the packing without the tedious and costly dismantling of the wheel.

Many existing designs were reviewed and discarded after elaborate laboratory tests. It was found that in most arrangements the packing was very sensitive to adjustment, and the margin between acceptable limits of leakage and friction was small. Further, the swelling of the packing due to absorption of oil or water usually quickly altered the original adjustment and friction became prohibitive.

The solution finally accepted was simple. Two round rubber rings placed between the blade and hub, separated by a lantern ring vented to the lower side of the blade, provided the seal. The design might have been further simplified by the use of a single ring, but the complex variation in water pressure around the blade stem defied laboratory analysis and the two-ring design was selected as being good insurance of performance.

The round rings under very slight initial compression gave surprisingly low friction. The arrangement provided ample space for swelling resulting from absorption of oil and water. It also provided for easy replacement without removing a blade by the use of a simple vulcanizing kit. The seal has met every expectation from the point of view of both friction and leakage. There has been no evidence of water in the hub, and in the early stages oil make-up was limited to one gallon a week.

The blade bearing design is not usual in North American practice. Each blade is carried on a single journal while the bending moment of the water load on the blade is resisted by two opposed thrust faces acting parallel to the axis of the blade. Advantages of this design are not conclusive. The short blade stem arrangement offered some gain in foundry practice and provided more space in the centre of the hub. It was also the arrangement successfully used in the past in several manually-controlled adjustable-blade propeller wheels.

The oil head was conventional in every respect, and we were surprised when trouble developed in two forms. An unpleasant bumping was felt in the head during certain phases of governing, and air sometimes entered the governor oil lines. Air entry was found to be due to a vacuum produced at the head by the unusually low level of the sump. The cause of the bumping was traced to an unbalanced thrust in the head due to different packing diameters in the oil lines leading to the blade servo. This thrust reached, under certain oil pressures, a value of 13,000 lb. uplift. Through a flexing of the exciter supporter beams, this uplift produced a movement estimated as 0.045 in. which registered on the feedback to the governor as a false blade movement. The prompt governor response and resulting change of thrust on the head caused sharp movements and hunting of the blades until a neutral position was obtained. A short series of sharp bumps on the platform was the result.

The existing head was replaced by a new design with balanced packing diameters to eliminate the deflection caused by changing oil pressures. Low-pressure oil lines were led to lantern rings between two sets of packing in each gland to prevent entry of air at sub-atmospheric pressures.

We still wonder why this trouble has never been reported before. Perhaps these problems are always pres-

(continued on page 99)

Methods and Trends in

AUTOMATIC COMBUSTION CONTROL

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Automatic combustion control is defined, and examples are given of basic control layouts for oil- and gas-fired boilers, with some methods used in combination fuel firing. Further examples include controls for a large-capacity unit and simplified control systems for package boilers. Components common to these systems are reviewed. New trends in techniques have emerged: (a) as regards solution of the control problem; (b) as regards presentation to the operator. Two fields of research are discussed briefly, and their significance for future controls mentioned. The paper finally examines some of the human factors involved.

AUTOMATIC COMBUSTION Control may be defined as an automatic system which: (1) proportions fuel and air supplies for optimum overall economy throughout full operating range; (2) maintains steam pressure constant; (3) assures correct gradient of pressure conditions from combustion chamber through to stack; (4) notifies and records operating faults; and (5) incorporates centralized means for manual control and smooth transfer to automatic. It may also provide furnace purge, and fan and flame failure interlocks. The automatic control of boilers includes several other problems such as feed water control, steam temperature control, etc., which, however, may not be dealt with in a paper confined to combustion control.

Figure 1 is an automatic combustion control layout typical of applications to oil-fired boilers of capacities 15,000 to 250,000 lb./hr. Fuel and air supply are regulated in parallel from steam pressure, but with a refining correction of fuel from the ratio between air flow and metered oil input.

The area meter, transmitting either pneumatically or electronically, is the oil metering device employed, and where there is continuous oil return two transmitters are arranged for subtraction. This is the preferred arrangement when burning oil alone, but for the smaller boiler capacities, provision of the oil meter is often avoided by applying to air supply a refining correction from the steam-flow/air-flow relation of the boiler meter, as is commonly done with pulverized coal firing for all capacities. The controls for air supply may be applied to either forced or induced draught or both in parallel, but in all cases, except pressurized units, the proper balance between forced and induced draughts is secured by adjusting one of these factors from a controller responding to the draught in the combustion chamber.

Fig. 1. Control applied to oil firing.

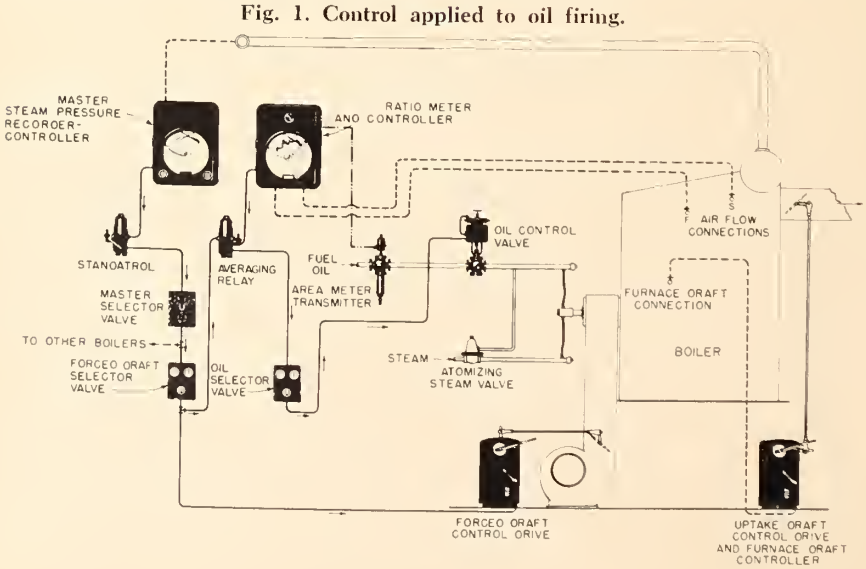


Figure 2 is a diagram of correct doctrine in the application of control to a gas fired boiler.

Gas flow and air supply are primarily regulated in parallel from steam pressure. A refining correction incorporating reset applied to gas flow from the ratio between metered air flow and metered gas flow assures precise proportioning for peak economy, and affords safety by virtue of a positive and rapid response in limiting gas admission to match air flowing.

Especially in oil refineries and chemical plants with supplies of by-product gas we encounter combination fuel firing with the requirement to use as much gas as possible. Figure 3 is typical of the solution applied to this problem on several boilers varying in size from 60,000 to 100,000 lb. hr. in three different refineries in Montreal East.

The master control signal is admitted to two computing relays for each boiler. In the first this is correlated with the output of a gas main pressure transmitter to determine the signal sent to the gas flow control valve. In the second the output from the transmitter measuring gas flow to the individual boiler is subtracted from the master control signal to determine the signal sent to the oil flow control valve.

The cams of the positioners of the oil and gas valves are characterized so that 1-lb. increments of the master pneumatic signal produce equal B.t.u. admission whether at the oil or gas valve. Such an increment, passing to the uptake damper control in the basic parallel response of the control system, will secure correct basic air response for either fuel. By properly correlating the proportional band adjustment of the first computing relay, the appropriate suppression on the gas main pressure transmitter, and the range of the master signal, maximum available gas usage is secured.

The proportional band adjustment for the second computing relay is selected so that reductions effected in oil input will, on a B.t.u. basis, closely match the increases in gas flow, and vice versa.

The normal variations in B.t.u. content in the gas and oil, and in pressure drops across the control valves, obviously limit the accuracy of the calibration of the responses of this gas-oil switching system, but the steam-flow/air-flow controller of the main combustion control system stands continuously ready to add a refining signal to modify total air supply, if needed.

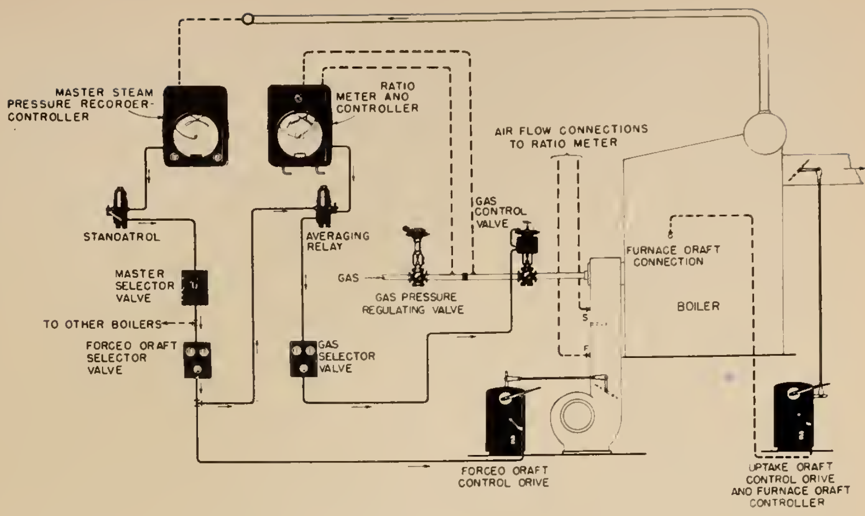


Fig. 2. Control applied to gas firing.

This scheme is easily added to existing control systems of correct design, and can yield highly lucrative reduction in gases lost to the flares.

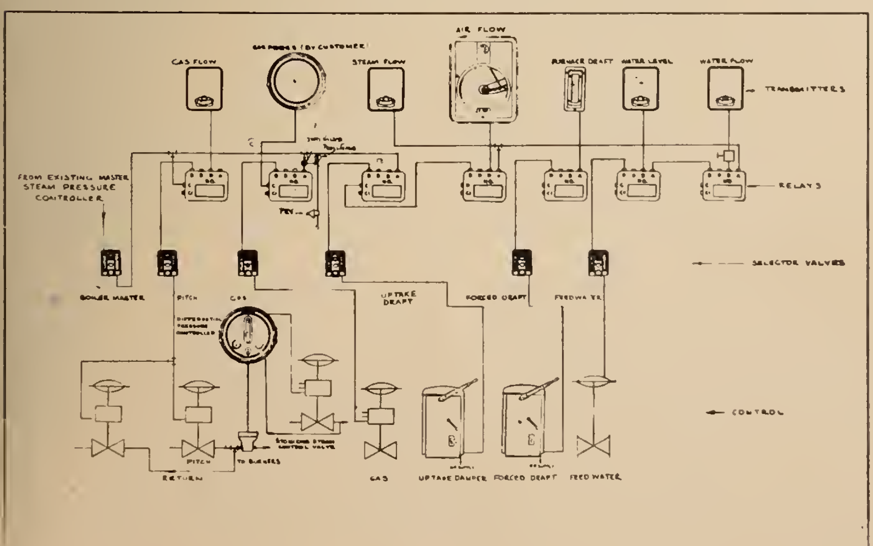
When burning oil and gas simultaneously, the complication of requiring two fuel measurements and their addition render it most practical to initiate the refining correction from the steam-flow/air-flow relation and to apply it to air. Figure 4 illustrates an installation where positioning one selector switch permits selection of steam-flow/air-flow correction when burning oil and gas simultaneously, or of gas-flow/air-flow correction when burning gas alone.

With normal refinery gases and oils, the cumulative effects of difference in excess air requirements and difference in flow effects of the products of combustion for the two fuels, make it practical to operate with little or no biasing of the corrective signal established by the steam-flow/air-flow controller, for the full range of proportions of the two fuels.

Frequently, however, we encounter a third fuel to be burned in combination, which has an entirely different B.t.u. content. The final check on excess air proportioning must in such cases be a recorder of % oxygen and % combustibles in the flue gases. As the curves of 0_2 content versus excess air percentage for the whole possible variety of fuels are almost coincident, analysis of 0_2 content provides continuous knowledge of excess air available in the furnace. This information may be used for either manual or automatic correction. The % combustibles pen, by detecting unburned gas in the flue gases, serves to detect faults in mixing, and in fixing the practical limits to excess air reduction. A smoke density recorder also often justifies itself from the savings that accrue when guidance is available to reduce excess air closer to the economical limit. For all multiple fuel firing, including solid fuels such as pulverized coal and bark, there is a definite trend to include continuous analysis for 0_2 and combustibles and to record smoke density. In a great many cases, e.g., refinery CO boilers and for auxiliary bark burning, 0_2 recording is quite indispensable.

For combination fuel firing, good control system design requires for each application careful examination of unit design, of fuel availabilities, of facilities for air measurements, and of suitability of the damper systems for their control purpose. Figures 3 and 4 illustrate methods adapted to specific problems and it should be ap-

Fig. 3. Control of gas and oil firing in combination.



preciated that, though alternative approaches may be offered, there will usually be one arrangement and choice of components that can excel all others in performance.

With the availability of Western gas in varying quantity, combination fuel firing will increase, and excellent answers to its problems, based on both refinery and past Western experience, will be forthcoming.

Figure 5 exemplifies the complement of components required and presently being built for a large high-pressure high-temperature boiler in Western Canada, with choice of firing pulverized coal, gas or oil (future).

At the other extreme in capacities fall the packaged steam generators for which simplified package control systems, as illustrated in Fig. 6, are available. These controls are of the simplified parallel or ratio variety, normally without a secondary refining correction. To merit the title of combustion control system, however, the damper drive and oil flow control valve must include means for characterizing their travels so as to achieve efficient fuel - air ratio throughout the whole operating range. In the system illustrated, this important function is accomplished by shaping cams in the air-operated positioning relays appearing on both forced draught damper drive and oil flow control valve.

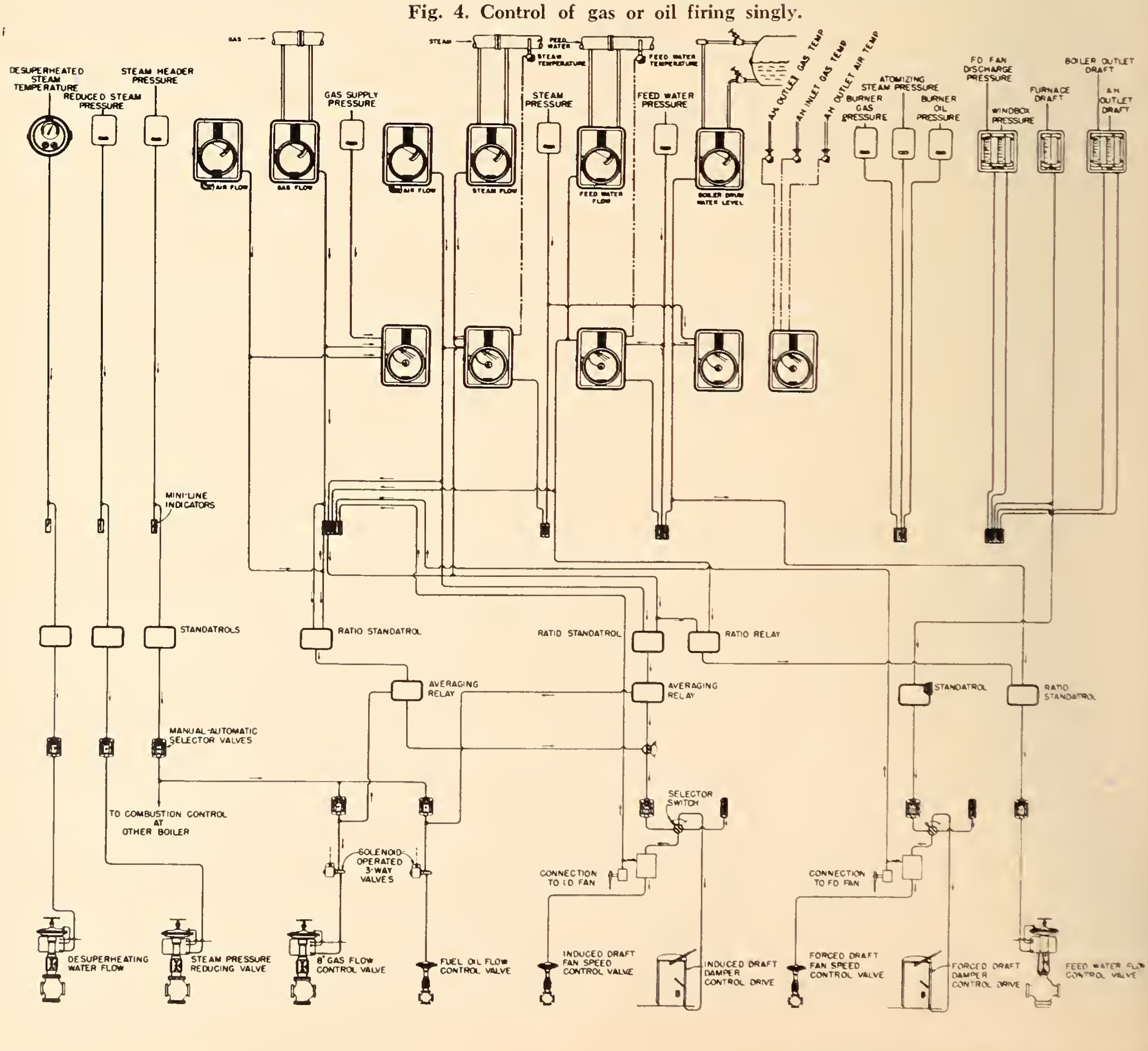
These package control systems incorporate interlocks for fuel shut-off from flame failure, from low water level, and from high steam pressure, and protective devices to assure low fire start and a safe minimum permissible fuel supply.

A tendency, shown two years ago, to specify fully automatic ignition for industrial package units fortunately appears to be waning for the causes which had always inclined boiler and control manufacturers against it. It involves an undesirable complexity of electrical switchgear and relays, which is normally not warranted, and which makes fault tracing by the user impractical, and results in unnecessary outage.

Having now viewed schematic control arrangements typical for a wide range of capacities, let us take a look at the components. (See Fig. 4.) To generalize, we find an increasing tendency toward local measuring devices transmitting a signal which may be used for indication, recording or controlling or any combination of those functions. Data continuously essential to the supervising operator are presented on grouped miniature indicators, operating faults declaring themselves by deviation from acceptable pointer pattern, drift from set point or alarm.

Data necessary only for loading history, efficiency calculations, preheater performance, etc., is recorded in related groupings on universal multiple-pen intermediate-size recorders, economically grouped on a panel that

Fig. 4. Control of gas or oil firing singly.



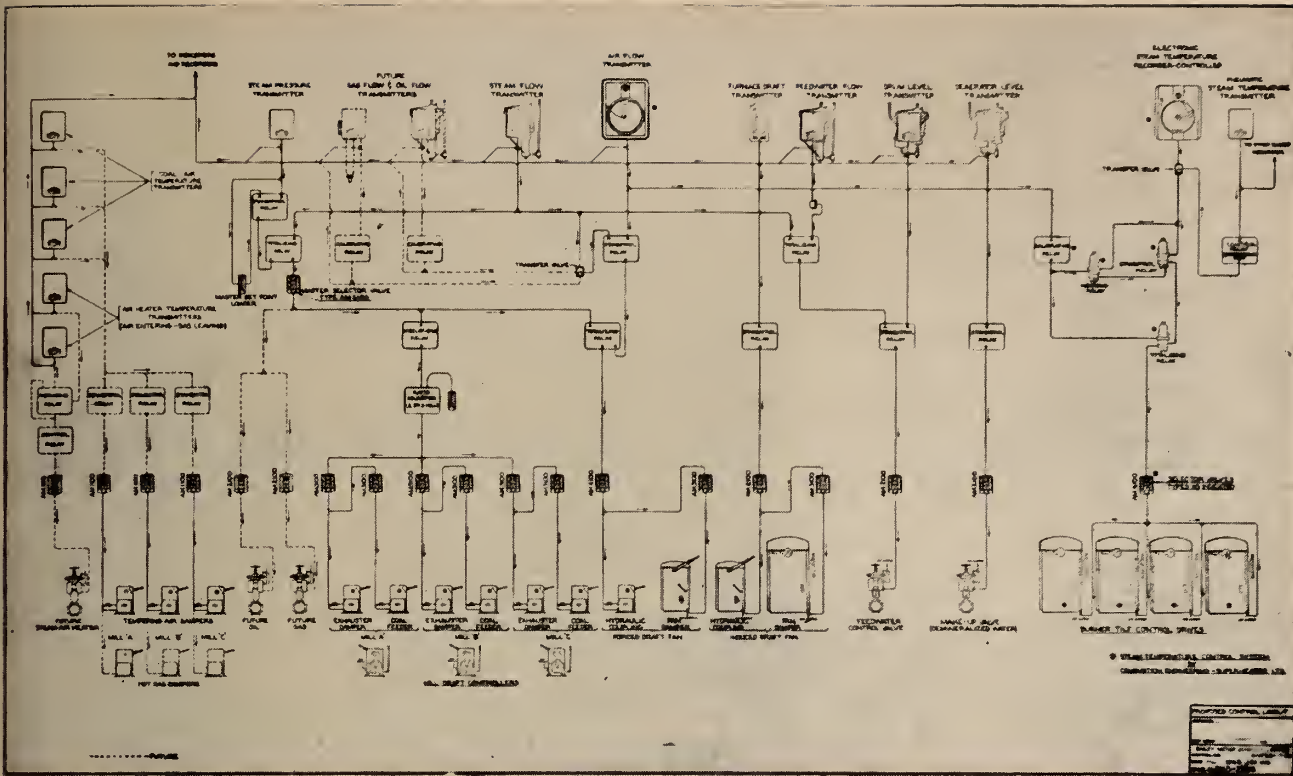


Fig. 5. Control components for a large boiler with three alternative fuels.

may, if necessary, be relegated to the background.

The signals that are to determine automatic control enter computing relays which provide proportional band, reset action, the addition of the refining correction, acceleration, and other functions as required. A given signal may be used simultaneously for two or more control purposes by introduction into separate computing relays, for example, the steam flow signal employed in the computation of the steam-flow/air-flow refining correction of the combustion control, in balance against the feed water flow signal in three-element feed water control, and as one element in steam temperature control. These computing relays need not be mounted in the control board, but may be racked elsewhere.

The outputs from the computing relays next pass to panel- or console-mounted selector stations which provide centralized manual automatic selection and bumpless transfer.

Control is finally effected by the power drives and valves connected to receive the signals from these selector stations.

Two important changes which emerge from this general consideration constitute trends in technique. One concerns the solution of the control problem, and is the adoption of the building block method employing standardized interchangeable and independent components. The other concerns data presentation and permits increased supervision per operator, by concentrating only indications of the essentials and the selector stations within reach of the operator, with the recorded factors in secondary prominence.

Perhaps the most important single factor in the success of the building block method is the achievement of a true universal recorder of intermediate size, precision built, with interchangeable plug - in components, dowelled, precalibrated and packaged. Figure 7 illustrates the exterior view, Fig. 8 the four positions for plug in components. Figure 9 shows the three most common standard components, namely, pneumatic and electronic receiving elements and the integrator. The pneumatic element can receive a standard pressure signal ranging from 3 to 15 or 3 to 27 psig. proportional to any factor such as flow, temperature, pressure, level, etc. The electronic receiving element is available in a wide range of measuring circuits including Wheatstone bridges, impedance bridges, potentiometric circuits suitable for voltage range spans from 2 mv. d.c. and up, etc., as required for the wide variety of factors to be recorded.

A multitude of receiver combinations are offered from these three components alone. Universality is completed by the availability of several further plug-in components such as the pneumatic controlling element, pneumatic transmitter, and direct-connected pressure element illustrated in Fig. 10.

An ingenious new inking system eliminates the mixing of recording inks by crossing records, and requires annual instead of daily attention. The reduced size of the receiver coupled with the new degree of record definition provides clarity of observation and interpretation for multiple rows of receivers on the same panel, resulting in a degree of panel economy unequalled by other methods.

Figure 11 illustrates the trend in technique of data presentation as described above.

As might be expected, current design often mixes former and new techniques as physical conditions and economy dictate best for any given plant. Pneumatic transmissions may intermingle with direct-connected instruments, and selector stations and miniature indications may fall on an inclined shelf integral with the recording panel.

In marine practice the same trends both in method and in data presentation are to be observed. In fact, space limitations and shock specifications imposed by naval design shared with central station needs in shaping their

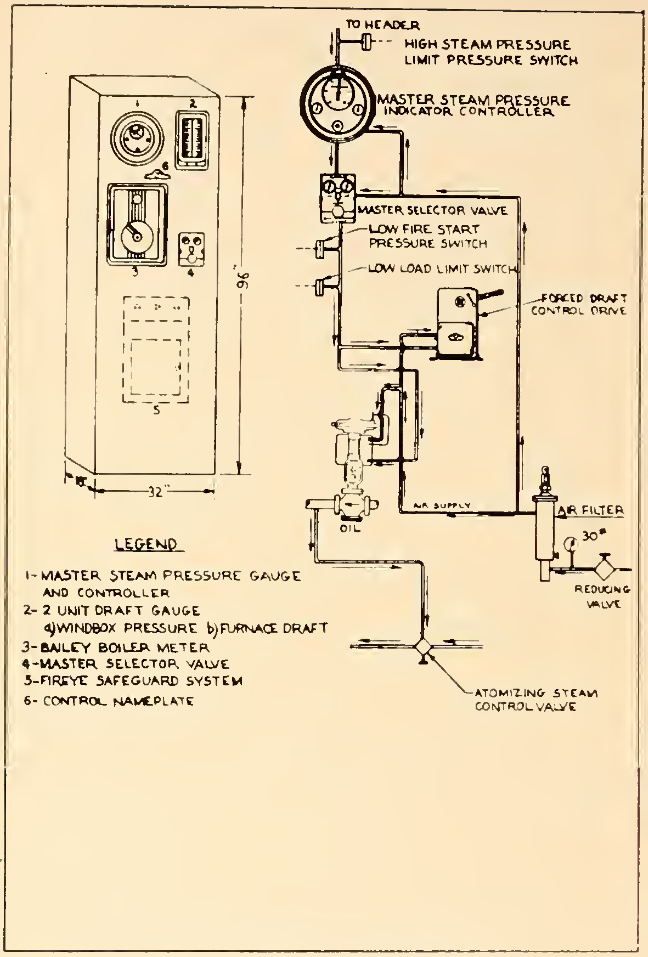


Fig. 6. Package boiler control.

Fig. 7. Intermediate size universal receiver.

evolution. As operating results from automatic operation have become more widely known, there has developed an insistent demand in the new marine construction for guiding and recording performance. It is to be expected that present fuels will persist for some time in both merchant marine and naval boilers.

If in any doubt as to the importance to warships of extending their fuel potential, contemplate for a moment the Battle of the *Bismark*, when Sir John Tovey, Commander in Chief of Britain's Home Fleet on H.M.S. *King George V*, after four days and nights of chase and search, himself came near to having to quit the area without bringing the *Bismark* to action, because he was approaching the limit of his fuel tanks, and when the destroyer *Mashona* was sunk after the same action, because she had overstayed her fuel supply and was condemned to a slow speed return to base.

For this reason, those who ponder naval tactics will find it difficult to believe that atomic plants will not inevitably power both submarines and the larger surface vessels. The added techniques for instrumentation and control as required for differing types of reactors, their steam generating and auxiliary systems have already been successfully worked out.

Electrical combustion control is again receiving attention in research and development departments in an effort towards improvement. The search continues for a simple electrical power unit capable of speed and precision comparable with that of the hydraulic or pneumatic power cylinder. The convenience of electrical signals for admission to printout and computing circuits adds some stimulus to this research.

The trend toward centralizing essential and related data in compact form has extended itself in steam electric generating stations to include the combining of control centres for boilers, turbines, auxiliaries, and (where applicable) load dispatching, in a single control centre. The results have been a decrease in supervisory and maintenance cost and improved performance through better coordination.

Obviously, in the control of the combustion process we have for some time been close to the possible optimum in economy, reliability, and flexibility. There still remains one area where an advance is being made. As in the past, its potential in the large steam electric generating station has provided the justification for its investigation. On the larger units fractional percentages in efficiency represent many thousands of dollars, and small variations in the efficiency of boiler, turbine, feed heating, and condenser systems continually occur and are often difficult to analyze. There is also the fact that on interconnected power systems, large savings reward the most economical incremental loading, and planning this demands precise determination of unit performance.

It became apparent, therefore, that an auxiliary complement of instrumentation might yield the desired results. Of this, one part would have to be of the highest possible precision and coupled to a computer with analogue record for performance monitoring. The remainder would be comprised of numerous primary measurements connected with selective fast scanning, digital printout, and programming for fault analysis and system study.

Where design of operating guides and controls had required rugged reliability and repeatability under continuous operation without instrument outage, this auxiliary instrumentation must be free for frequent removal from service for calibration checks, and the service of the scanning and programming equipment need only be intermittent. Moreover introduction of this auxiliary equipment could permit further simplification of the basic instrumentation provided to guide the operator. Also the user's need for large departments for result determination, interpretation and record could be eliminated. Figure 12 schematically illustrates this approach, which is already adopted in some plants in the U.S.A. and under study for others.

The success of this approach involves meeting several further requirements than does the application of computers in business, and progress is being made in three main fields of activity.

(1) proper selection of, and improved precision in primary measurements;

(2) the development of a high quality continuous performance computer with lock out on component failure; and

(3) considerable improvement in existing data programming equipment to increase operating time and reduce maintenance.

Performance determining equipment, as illustrated in the centre group of Fig. 12, may deliver continuous information of boiler, turbine, and heater cycle efficiencies, turbine heat rate, cost per M.w.h. output, etc. and deviations of the same from standard.

Figure 13 is a simplified schematic of one method of derivation of typical information. Standard electrical signals proportional to selected accurate measurements, and certain manually set signals derived from known data and tests, enter computing and comparison circuits whose recorded outputs represent performance and deviation from standard.

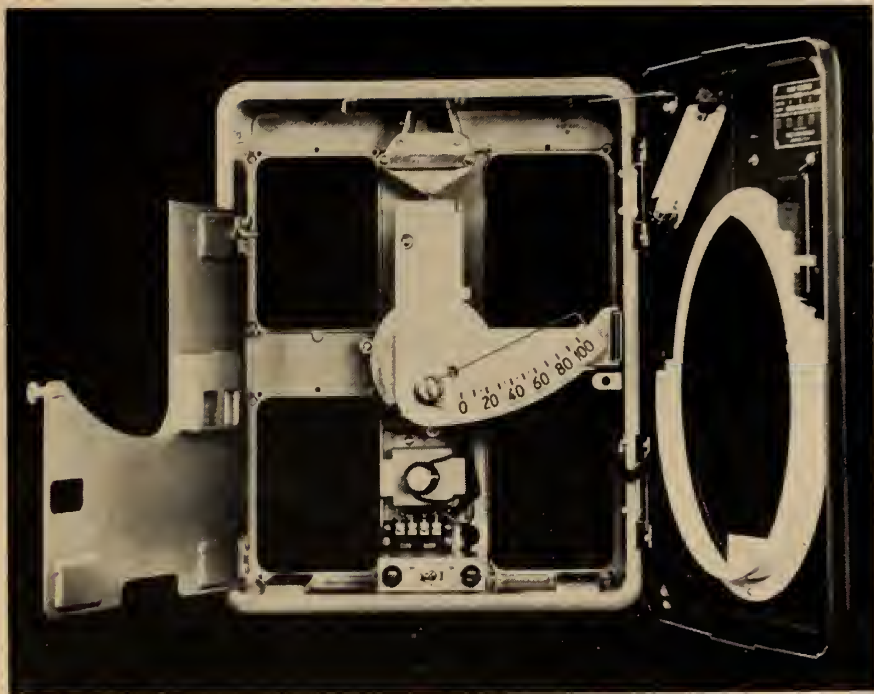


Fig. 8. Positions for precalibrated plug-in components.

For boiler performance determinations, the recognized accuracy of the heat balance method has pointed the way to the selection of feed water flow, excess air percentage, and the appropriate water, steam, and gas temperatures as the correct basic data. Questionable steam measurement at high pressures and temperatures, where steam table values have been based more on extrapolation than determination, may be completely avoided. Typical problems of precision are the wick effect of thermometer wells and choice of representative sampling points for flue gas temperature and analysis.

The fact that errors in determination of heat losses in flue gas, ash, and radiation show up in boiler efficiency calculations at approximately one tenth their own percentage, contributes to precision.

The test equipment represented by the group at the right of Fig. 12 may be designed for any studies intended whether simple or complex. Figure 14 illustrates components of a system

Fig. 9. Pneumatic and electronic receiving elements and integrator.

Fig. 10. Pneumatic transmitter, pneumatic controller, and pressure element.

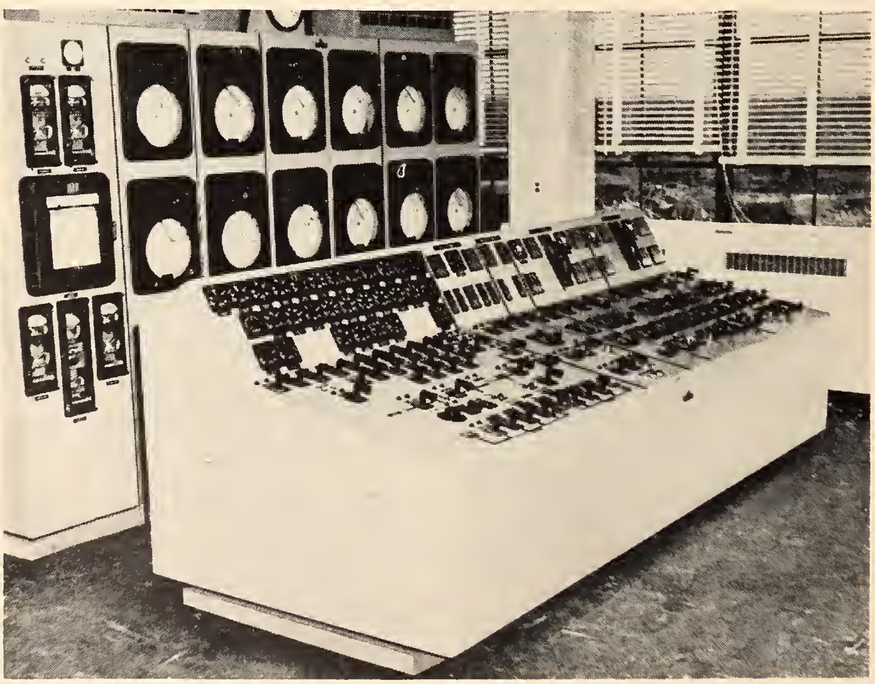
designed to analyze the operation of a large steam generator. At the touch of a button, analogue scanners connected to accurate measuring devices, begin to gather sequentially selected data. The analogue signals, certain preset data, commands to the computer, and necessary distinguishing symbols are digitized, properly sequenced, and punched in code on continuous tape for transmission by teletype to a remote electronic computer for processing.

In Fig. 14 the digitizer is the cabinet at the left, the control console is in the centre with the tape perforator mounted above it, and the teletype transmitting equipment appears at the right.

Having been automatically coded in the form suitable to the computer, it can be quickly processed mathematically and the results sent back to the boiler site by teletype.

In the past, when proving out a new steam-electric unit and determining optimum operating conditions, the requisite analyses have often required weeks of work by a team of test specialists. This new method of data gathering and processing shortens this to minutes, provides performance data of a type previously unobtainable, and is expected to solve problems that hitherto defied analysis. As it need be used only intermittently and for short periods, one assembly of equipment can be connected to test any boiler that has the necessary primary measuring elements. Likewise it can be moved from plant to plant. On large and complex units, a permanent installation for frequent test may, however, be justified.

Fig. 11. Mini-line approach: console and background panel.



Until reliable synchronized and related information and the effects of variables are capable of rapid computation, a complex process cannot be thoroughly understood and the potentials from the control of its components cannot be evaluated. Important need for probing additional data points and analyzing their relations may have completely escaped attention. However, scanning and digital printout alone achieve little. It is when they become a means to the prompt examination of immediately processed test and fault calculations, and there is a continuous presentation of computed performance and deviation, that the objective may be achieved.

A whole vista of possibilities opens out for good data scanning, if coupled with system analysis and performance computing, for large boilers, for a broad range of equipment associated with them and for many continuous flow processes. The example of the past would suggest that simplified forms of this equipment might be expected to find a place on boilers of intermediate capacities for design studies, boiler trials, and for operating guidance.

Engineering Personnel

The most important factor in control development being engineering

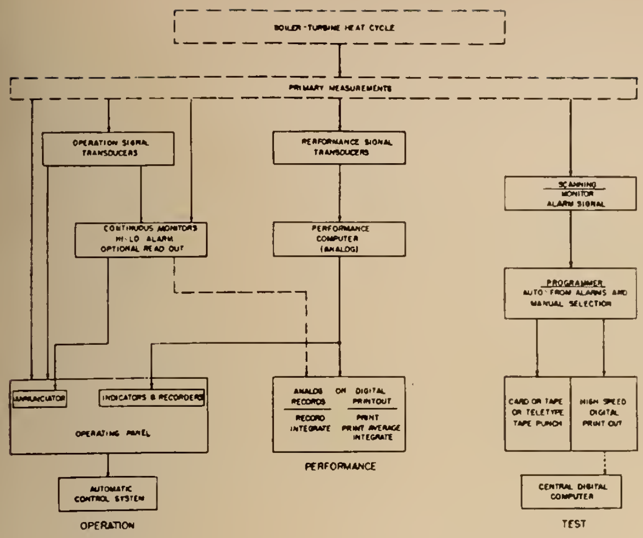


Fig. 12. Schematic of instrumentation arrangement for operational guidance, performance determination, and test.

Fig. 13. Schematic of analogue type performance determination.

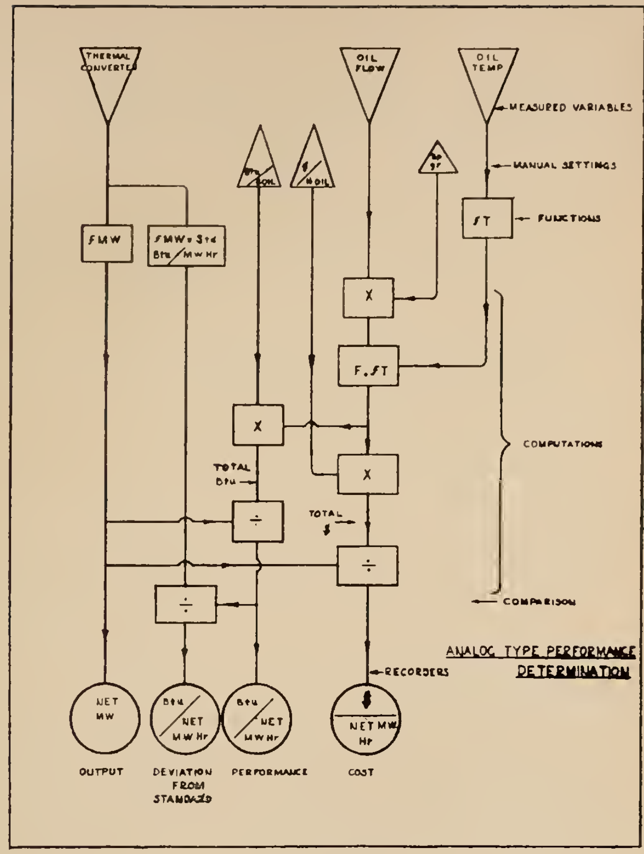


Fig. 14. Equipment for digital printout, programming, and teletype transmission to electronic computer.

personnel, it is fitting that we should appraise them and note their direction.

Biologists and students of prehistory have proved one billion years of life and at least two hundred thousand years of human occupation on this planet, and that nature laid down much of the earth's resources of fossil fuels (coal and oil) at least two hundred million years ago.

Modern man, multiplying unrestrained at a rate which could shortly outrun the earth's supply of chemicals essential to life, such as phosphorus, seems bent on exhausting the energy resources. He is beginning to pillage the energy stored in uranium ores with equal abandon.

In an age which is certain to be looked back upon as one of irresponsible waste, the instrument engineer and technician have made conservation their profession.

Two trends developing among Canadian instrument personnel merit attention, one inviting correction, the other gratitude.

The economics of manufacturing specialized products for large as compared with small markets, and the forces affecting the training and employment of technical personnel have tended heavily to develop far too great a dependence upon the re-

(Continued on page 79)

The Role of the TECHNICAL ASSISTANT in Industry

J. R. Houghton, M.E.I.C. *Assistant Works Manager, Northern Electric Company Limited, Montreal*

A GREAT DEAL HAS been said in recent years on the use of technicians or technical assistants in engineering work, and particularly their relationship with professional engineers in carrying out such work for industry.

The use of technical assistants in industry warrants study and discussion by engineers. It should be interesting to all of us because the great majority of engineers are now employed in industry of one kind or another. The real interest is probably not so much the present role of technical assistants but rather how technical personnel ought to be used in engineering industry and what action can be taken to improve their position in the future. There has been a tremendous growth in industry, particularly in the technical aspects, and the engineering profession has not long been widespread in industry. The prospects for industrial expansion in Canada and the increasing technical complexity in all branches of industry present a definite problem in the efficient assignment of scientists, engineers, and the various levels of technical personnel to technical work. Whether or not there has been a shortage of engineering and technical personnel, there is no doubt of the future shortage problem unless we find ways to improve the utilization of technical manpower and to establish working assignments which challenge the potential of each of the levels of technical skill available to industry.

Dr. James Killian* stated not long ago that the expansion of industry will only be possible if there is an adequate supply of scientists, engineers, and technologists. He said that the shortage was perhaps not a general shortage of numbers as much as a shortage of specific talents and skills, that is, a shortage of the more highly talented. This shortage is probably accentuated by the inadequate use of the talent available.

Though technically trained men are used in many industrial fields—in production, inspection, sales, purchasing as well as in engineering departments this discussion is limited to the use of technical assistants on engineering work, and the subject regarded from the point of view of the engineer and the administration of the engineering function in industry.

*Former president, Massachusetts Institute of Technology; special assistant to the President of the United States.

DEFINITIONS

The first difficulty is that of defining technical assistants, technicians, technologists or whatever other term may be used for this overall group of skilled people working in the engineering areas of industry.

Technical assistant can be considered as covering a wide range of personnel whose skills extend from craftsmen to professional engineer.

A comprehensive definition developed by the Conference of Commonwealth Engineering Institutes is: "an engineering technician is one who can apply, in a responsible manner, proven techniques which are commonly understood by those who are expert in a branch of engineering or in those techniques especially prescribed by professional engineers. The techniques employed demand acquired experience and knowledge of a particular branch of engineering combined with the ability to work out details of a task in the light of well-established practice".

More simply, technical assistants in engineering are those who, although not professionally qualified, are capable of undertaking assignments which require more formal education and more theoretical knowledge than is required by the skilled craftsmen. On the other hand, the technical assistant is particularly useful on these assignments because of the practical skills and abilities which he has. Technical assistants' work then involves some of the knowledge of the professional engineer and the skills of the craftsmen.

The classical distinction between engineering and technical work is that the engineer plans while the technical assistant makes and does; the engineer creates, the technical assistant applies.

LEVELS OF TECHNICAL ASSISTANT

It is obvious from these attempts to define technical assistants and their assignments that a very broad field is involved; a tremendous variety of jobs which require various levels of skills and of training and of educational background. Some skilled craftsmen graduate into technical assistant assignments. For example, a toolmaker may demonstrate a flair for drafting and design or for technical trouble-shooting and bring his toolmaking and metal-working skills and training into use to good advantage in these fields even although his educational background may be high school or technical school graduation or less. On the other hand, technical assistants with an educational background of junior or technical college of one type or another may be capable, for instance, of undertaking the detailed design and prove-in of complicated electrical test facilities, relieving the design engineer for the more fundamental planning and circuit development engineering.

JOB DESCRIPTION

To me, this is the principal area for discussion and for improvement. Those of us who are involved in administering engineering work in industry must develop better ways of defining or describing the different types and levels of technical assignments involved in carrying out the engineering departments' work. This is primarily job description, but with a difference because it is necessary, with increasing technical content of the assignment, to define the skills and characteristics of the man required to perform the job as well as to describe the job itself. Only in so tackling the problem can we subdivide job assignments to get full efficiency from the various available levels of technical personnel.

A fundamental point is that this job description or work assignment analysis involves defining both the technical skills and the educational background which are required for a technician to meet the needs of the various levels of work in an engineering department.

This is quite a difficult problem, perhaps particularly in Canada, where industry is relatively young and technical education is certainly still very young. Not only is there a need for more technical institutes at the post-high-school level or junior colleges but there is also a need for a national educational standard; that is, some means of comparing technical education and training, such as the National Certificate system in England, which has become so well known in this country in recent years. Such a system not only provides for the recognition of the educational background of a technical assistant but also provides the means for a technical assistant to progress from one level of education to another in a planned and recognizable manner. But this takes time and there are other things which can be done in the meantime.

ENGINEERING ORGANIZATION IN INDUSTRY

In order to bring some of these statements into focus, let me discuss briefly the organization of some of the engineering functions in my company, which is fairly typical of manufacturing industries, at least in the problems involved. The company, which requires a large engineering and technical staff both in the engineering design and in manufacturing, is organized on a divisional basis and there are several engineering departments associated with the divisions. In common with other companies, we have developed a fairly detailed technique for evaluating different levels of work and types of jobs, but there is still difficulty in deciding just which jobs can truly be classed as technical assistant to engineering work. Taking as the criterion the higher levels of technical work, however, there is at present a ratio of technical assistants to engineers of approximately 1:1 throughout the engineering departments. This compares with a ratio of approximately 1:2½ in 1949. We have put a lot of study in recent years towards increasing the direct support of technical assistants to engineers, but we still have a long way to go. Some studies suggest that, within the next ten years, this ratio will have changed to nearly 2 technical assistants for each engineer.

To illustrate, the manufacturing engineering organization in one of our larger manufacturing divisions is responsible for: (1) determining the methods of manufacture which shall be used for each product; (2) providing the facilities for manufacture; (3) developing the manufacturing shop layouts and issuing manufacturing instructions and specifications; (4) developing each new product and the facilities involved into a production unit; (5) cost-reduction engineering throughout the manufacturing shops; and (6) the provision of engineering and technical advice, assistance and trouble - shooting throughout the manufacturing shops.

The organization includes methods engineering for manufacturing and associated with the trades groups (toolmakers, electricians, millwrights, etc.); mechanical design (machines and tooling); factory engineering; and electrical test facilities design.

Much of this work involves top level engineering. It requires both the specific knowledge and skills of the professional engineer and his broad analysis and appreciation of the relationship of the engineering problem to the overall business problems. Much of the work however can be, and should be, handled by technically-trained men associated with the engineers. There is a wide variety of work, and hence the opportunity to make use of a variety of skills and levels of training either independently or in combination. Some of the categories of technical work have been selected to illustrate the functions of technical assistants and also the background of experience and education which is considered desirable.

TECHNICAL ASSISTANT ASSIGNMENTS – MANUFACTURING

A. *Technical Assistant, Grade 1— Shop Methods*

Functions — (1) Assists engineers on routine technical problems encountered during manufacturing. (2) Follows up delays in paper routines involving shop layouts and checks these against standards for errors. (3) Gathers information on shop outputs, material handling routines, shop equipment, as directed by engineer.

Educational Requirements—Graduation from high school (junior matriculation) with practical technical experience equivalent to 3½ years of training (equivalent to 7 to 10 years' service), must have mathematical ability and interest in science.

B. *Technical Assistant, Grade 2— Manufacturing and Inspection Layouts*

Functions — (1) Prepares layouts for manufacturing and inspection processes. (2) Calculates quantities of raw material needed and determines dimensional requirements. (3) Calculates weight of plating surface areas, etc. for manufactured parts. (4) Determines manufacturing sequence and equipment to be used and specifies particulars such as speed and feeds for production equipment. (5) Decides sequence and number of inspection operations and specifies packing methods. (6) Conducts shop tests on practicability of revised layouts.

Educational Requirements—Graduation from technical school plus 5½ years of planned training (equivalent to 11-16 years of service).

C. Technical Assistant, Grade 3—
Product Planning

Functions — (1) Analyzes new drawings to determine if parts are to be made internally, sub-contracted or purchased. (2) Recommends internal manufacture if savings are evident. (3) Assigns manufacturing routine and makes a preliminary estimate of tooling costs. (4) Analyzes quotations from purchasing dept. and designates source of supply on items to be manufactured outside. (5) Deals with engineers, manufacturing groups, tool design, and purchasing.

Educational Requirements—Graduation from technical school plus 6½ years of planned training (equivalent to 13-20 years' service).

D. Technical Specialist, Grade 4—
Shop Methods

Functions — Investigates and settles technical problems in the production shop and expedites material flow when technical problems are limiting feature. Handles portions of development projects. Works under minimum guidance from engineers.

Educational Requirements—Graduation from technical school or Junior Matriculation with additional related technical courses with 5 to 6 years planned training (equivalent to 15-18 years' service).

TECHNICAL ASSISTANT ASSIGNMENTS–FACILITIES DESIGN

A. Technical Assistant, Grade 1—
Test Facilities Development

Functions — (1) Assists engineers in the development and improvement of electrical test equipment. (2) Prepares and modifies specifications for less complex equipment units under engineering supervision. (3) Proves in test equipment and uses laboratory equipment such as meters, oscilliscopes, bridges, analyzers, etc.

Educational Requirements—Graduation from technical school plus added courses in radio and electronics, or three years' course at Ryerson Technical College, or equivalent, plus 3 years of planned training (equivalent to 6-9 years' service).

B. Technical Assistant, Grade 2—
Test Facilities Design

Functions — (1) Develops and designs test equipment for process and final inspection under the supervision of senior engineer. (2) Compiles instructions on technical description of equipment. (3) Investigates shop complaints regarding the need for or the use of test equipment.

Educational Requirements—Graduation in electronics from a technical college similar to Ryerson, plus 4½ years of planned training (equivalent to 9-15 years' service).

C. Technical Specialist, Grade 3—
Die, Jig, Fixture Design

Functions — (1) Designs complex dies, jigs, and fixtures as required in the manufacturing of intricate parts for telephone equipment and apparatus. (2) Works under minimum guidance from engineers.

Educational Requirements—Graduation from technical school with additional formal study on mechanical subjects such as tool design, metallurgy, etc., or holders of technical certificates such as HNC from the U.K., plus 8 years of planned training (equivalent to 15-20 years' service).

Some typical technical assistant assignments have been described to bring out some of the problems involved. Many of these jobs which can be handled by the top qualified technical assistants are very close to the function of the professional engineer in the field, in fact, it is difficult to develop the difference in a straight job description. The difference exists —first, in the narrower field of specialization of the technical assistant, and, second, the broader approach to the problem by the engineer as compared with that of the technical assistant. There is thus the complication of the amount of skill, ability, and actual training of the particular engineer or technical assistant assigned to a given area. It must be recognized that the younger less-experienced engineer or "engineer in training" may be less competent than a senior technical assistant in handling a particular job. In his early years, an engineer must undertake work which might be described as of technical level in order to gain the necessary practical experience to develop his full potential. He can and does learn from technical assistants. Thus we find overlapping of assignments in an engineering department, between engineers and technical assistants, and therefore overlapping of grade ranges.

Truly to perform the engineering function requires a full professional engineering education and the ability to apply this knowledge creatively. To do this an engineer must add practical experience to his fundamental knowledge. The successful engineering technical assistant requires high skill in at least one technical specialty and, as he succeeds to higher level work, he must add to his practical skills a continuously higher level of education. The degree to which a technical assistant approaches professional status is difficult to define and is really a matter of individual ability. A measurable level of technical education is needed, and means should be available for technical personnel to add progressive stages of such education and to obtain tangible recognition for it.

FUTURE ROLE OF TECHNICAL ASSISTANTS

There seems to be no doubt that we will need more engineers and more technical assistants in industry in the future. Fifty years ago, the ratio of technical personnel to others in industry was 1 in 300; now it is more like 1 in 50. This trend is increasing as a result of technological improvements in products and in manufacturing processes. In my company, the current ratio of technical employees to total is 1 in 20 and analysis indicates that 10 years from now this ratio is likely to be 1 in 12.

If we accept the fact that there is a need for scientists, engineers, and technical assistants, we ought to discuss what action can be taken to help fill this need. Specifically, what can the engineering profession do to assist in improving the supply and the calibre of technical assistants for engineering work? What ideas do engineers have and what steps can they take to bring these ideas into action? Both at E.I.C. and at C.P.E.Q. there are committees studying this problem. Also the A.P.E.O. recently acted to encourage the recognition and establishment of standards for various levels of technical assistants.

It seems there are three areas in which to work.

(1) There is the work which can be done in industry by engineering departments and administrators. This involves analyzing the sources of people who can be developed into technical assistants of one level or another. Sources which exist now are the high schools, technical institutes, and such technical colleges as are already in operation. A principal source is existing industrial staff who can be developed to become capable of handling technical work. Industry is already doing a lot of training to improve the abilities of its employees for technical work, but on predicted needs for the future much more training or training of much greater

numbers is needed. However, engineers can only do this if they can justify the costs to management.

Industry is eternally interested in avoiding any unnecessary expenses. If we honestly believe that we can improve the efficiencies of our engineering departments by making greater use of technically skilled people, then we must demonstrate to management that the costs of developing technical assistants are justified by the resultant savings.

There are many ways of developing technical assistants. Internal training programs can rotate employees through desired experience and give them specific courses in the technical skills required. Tuition refund plans enable employees with suitable qualifications to take evening studies in desired subjects. We have a long way to go towards the use of the system of part-time day release for educational study, which is very common in the U.K. through the National Certificate system.

(2) A second means of augmenting the supply and the calibre of technical assistants exists through improving and making available more facilities for evening study. A pressing need here is for the development of a standard of comparison for evening study courses so that credits can be given of recognized status.

(3) The third area for action, particularly in Canada, is technical education and training at technical institutes. In all recent Canadian conferences on educational matters, and also in the study work done by organizations such as the Industrial Foundation on Education, it is generally agreed that there is a need for a decided increase in the number of technical colleges of the post-high-school level in the various provinces of Canada. Quebec has an excellent set of technical institutes but is low on facilities for education between the level of these technical institutes and the university level. In Ontario, Ryerson Institute is the best example of the higher level technical college and there are other institutes of this type beginning to operate or under organization in at least three other cities. There is no question but that Canada will need more university graduates, and therefore more universities or radical expansion of existing ones, but at least the universities exist, whereas to fill this sub-professional gap it is necessary to bring into existence many technical colleges or institutes. If the engineering profession really believes this future need for technical assistants exists we ought to be able to help analyze the need and we should be able to assist in organizing the means to fill the need.

CONCLUSION

I have attempted to outline some thoughts concerning the role of technical assistants in engineering industry, from my own experience, and have attempted to be practical. Perhaps the points I have tried to make can be summarized:

(1) Certainly there is a growing need in industry for well-trained technical assistants.

(2) There is a need to develop a system of recognized status for technical assistants.

(3) This recognition should provide a stimulus for technical assistants to continue to improve their level of competency.

(4) Improved educational facilities are required to provide for this improvement in status.

The aim should be to provide education and training to develop all technical personnel to their maximum potential. The engineering profession has a definite interest, and should be able to assist in improving the future assignments of both technical assistants and engineers in carrying out engineering work.

We are constantly reminded that the rate of technological progress is increasing dramatically and that more thought must be given to these problems of increasing our capacity for engineering and scientific progress.

BEECHWOOD *(continued from page 55)*

The reactance relay for distance measurement is unaffected by arc and tower footing resistance. The relay scheme adopted may be extended and carrier relaying utilized if required in the future. Three-phase, high speed reclosure may be added if required. These relays may be applied to parallel lines having appreciable mutual coupling by cross-connecting the current transformers in the parallel lines. For the phase-ground fault relays, a scheme of sound phase compensation is used to ensure correct selection of the protected zones.

Of interest in connection with the relay installation at Beechwood is the relaying for the 69 kv. tie line with the Maine Public Service Company. The relay scheme is as listed above and, in addition, carrier relaying was added to give instantaneous clearance at both ends of the line for faults over the entire length of the line. This installation has an international aspect, and required the coordination of the following apparatus by the several engineering groups concerned.

(i) Identical protective relays were supplied for the two ends of the line. These relays are of the same type and manufacture, and were supplied by American and Canadian manufacturers respectively.

(ii) High speed, three-phase reclosing relays of different manufacture, but having similar dead time intervals, were supplied at each end of the line.

(iii) Identical carrier installations were provided for the two ends of the line. These two carrier installations were engineered in the Montreal office of the supplier. The equipment was manufactured in Europe and supplied through the Canadian and American offices respectively.

(iv) Different circuit breakers were employed on the two ends of the line. The circuit breaker at Beechwood is an air blast breaker of European design and Canadian manufacture. The breaker at Flo's Inn near Presque Isle on the American end of the line is a bulk oil breaker of American manufacture.

It is pleasing to report that extremely satisfactory collaboration was achieved among all parties concerned in this rather interesting sample of international cooperation on the technical level.

ACKNOWLEDGEMENT

The engineering design of the Beechwood Development authorized by The New Brunswick Electric Power Commission through the Honourable Edgar Fournier, Chairman. Mr. J. L. Feeney, M.E.I.C., then chief engineer and now a member of the Commission, and Mr. R. C. March, project manager, represented the Commission during construction. Mr. R. E. Tweeddale M.E.I.C., now chief engineer, acted as liaison engineer during the preliminary studies.

Dr. R. E. Heartz M.E.I.C., president of The Shawinigan Engineering Company Limited, directed the studies and design of the project.

INSTRUMENTATION IN INDUSTRY

PULP AND PAPER

This is the second in the series of articles on instrumentation in twelve Canadian major industrial groups. It deals with instrumentation in Canadian Pulp and Paper mills at various plants across Canada, producing sulphite, pulp, paperboard, kraftboard, bleached kraft, crepe wadding, newsprint, and fine and specialty papers.

In the entire Canadian pulp and paper industry it has been determined by the instrumentation committee of the CPPA that the value of instruments used today is close to $23 million or some 1½ per cent of its total capital investment. There are almost 60,000 instruments in use. The largest number used by any one company is 3,000 and the smallest number used is one. Specialty paper mills are the most highly instrumented, while newsprint mills use the fewest with 1 unit per ton of capacity.

Statistics of the Industry

Canada's Pulp and Paper Industry is one of the few leaders in manufacturing which can boast of a yearly output valued at more than a billion dollars. Four-fifths of the total output moves abroad. Almost a third of the U.S. wood fibre requirements comes from Canada. Pulp and paper accounts for about 5 per cent of Canada's gross national product. In 1957 the 6.4 million tons of newsprint, 10.2 million tons of wood pulp and some two million tons of paperboard and building papers was valued at almost $1.4 billion.

There are eighty pulp and paper companies operating some 130 mills in eight provinces, and employing some 335,000 workers in forests and mills. Canada has 26 companies making newsprint. They operate 146 newsprint machines in 42 mills with a combined capacity of six million tons yearly. Paperboard plants turn out 900,000 tons a year, valued at $125 million. Output of wrapping papers and fine papers at another 900,000 tons, valued at some $135 million yearly, is produced in 28 mills.

During 1958 the industry as a whole operated at about 80 per cent of capacity at mid-year, a new low for the operating ratio, but showed a modest recovery during the last half of the year. The overall demand for the industry's products declined about 5 per cent from the previous year.

From replies to a questionnaire recently circulated by *The Engineering Journal* among Canadian pulp and paper manufacturing companies, the following information as to the extent and practices of instrumentation in their respective mills is summarized. The information given, it is hoped, will not only be of value to instrument engineers within the pulp and paper industry itself, but will be usefull to other industry groups whose instrumentation will be covered in articles of this series in subsequent issues as a comparison with their experience.

Power is Metered or Checked

Power consumption by pulp and paper mills, including use for driving machinery and for electric-steam boilers, represents a greater portion of total production cost than obtained in most other industries. It is therefore generally found that both input of purchased power and output of developed power are metered or checked. In cases where the local utility serves few other customers, of course, this metering is less than necessary.

Steam Power Plant Instruments and Their Uses

Widespread use of instruments is found in the steam power plants for combustion control on thermal units, and for flow, feedwater, furnace temperature, gas and air flow. Some steam plants have automatic pressure recorders, steam flow meters on main steam lines and de-superheater controls on some of them, liquid level recorders, level controls on water tanks, timer controls, etc. The larger mills often have typical combustion control on main boilers and minimum base loading control on others, while elsewhere turbine flow meters and level controls for pressure reducing etc. are used. A recent innovation is continuous watch over the furnace by TV.

Capital costs per mill for steam-plant instruments only, exclusive of installation costs, vary from between $1,000 up to as much as $100,000 for a medium-sized fully automatic mill. On larger mills steam-plant instruments may represent an investment of $185,000 and even more in some instances.

Instruments are used by all companies reporting on steam processing plants for process control, and pressure reducing stations are frequently found throughout the plants. In some smaller plants heating is taken from steam mains. In no case did replies indicate separate plants were maintained for heating and power.

Who Specifies the Requirements?

The practice for determining instrument requirements for steam boiler plants appears to be to rely on the experience of the Company's engineering staff, and or the instrument section of the control dept. and, occasionally, of mill personnel. For boiler house system design, advice is sometimes sought from instrument vendors, particularly in special cases. Here, it depends on the size of the mill and the complexity of the instrumentation desired.

Instrumentation in Processing Plants

Most of the mills reporting, regardless of size or end-products, had been established 30 to 40 years ago. From their replies it was evident that prior to 15 years ago instruments were not widely used except in the boiler plants. It has been only during the postwar period that most of them have invested heavily in instrumentation for processing, and particularly during the past five years. One of the oldest newsprint mills in Canada, however, reported process instrumentation had been installed in its original plant 44 years ago.

Instrumentation is used in large up-to-date paper mills in their processing for measuring or controlling temperature and pressure, flow, acidity or pH, stock consistency, level humidity, differential temperature and pressure, position, fuel and wire guiding, weight, flow ratio, basis weight, moisture of paper, speed and speed ratios. Control of the cooking cycle in digesters is effected by the control of temperature and pressure, while the proper liquor charge is controlled by measurement of level. In washers, control is effected by control of flow and the consistency of the stock. Level recording of the various stock chests is the basis of control in the screen room, with flow controls for the supply of alum, sodium silicate, etc.

On the paper machines there is a speed recorder, and level-control on the head-box, with control of dryer temperature by temperature or pressure. Consistency is also recorded and regulated. In the Bleach Plant there is measurement and control of water, gas, stock, level, etc., and SO_2 and oxygen are also recorded and controlled, Beta meters are used for basic weight testing. In the chemical recovery plant there is flow control of waste liquor to evaporators and pressure, temperature and level control over furnaces. One new papermill uses a recording spectrophotometer and electric peak-load controllers.

Most Instrumentation for Process Control

As a general rule about 75 per cent of the investment in instruments, in terms of dollar value, is for process control, with the balance of 25 per cent being for measurement, divided roughly as follows: flow 30 per cent; level 25 per cent; pressure 15 per cent; temperature 15 per cent and miscellaneous 15 per cent. It is not unusual for a large paper mill to have as many as 1,500 controlling instruments installed.

Requirements of and uses for processing plant instruments in the case of small installations are generally determined by the Company's own staff. Control systems are designed usually by the staff or the Company's engineering office. Instrument manufacturers are often called in for advice, while consultants are generally called in for larger installations.

Time and Money Saved by Instrumentation

Replies to a question as to time, money and material savings effected by instrumentation disclosed a reluctance or inability to give definite information. One of the largest newsprint and sulphite pulp mills made the following comment: . . . "Very little savings in manpower cost; in most cases instruments are employed to control variables that a man could not control; most savings are the result of decreased equipment 'downtime', quality, uniformity elimination of safety hazards, etc. In fuel consumption it is estimated that as high as 30 per cent savings may have resulted over hand-firing, as well as due to the safety of automatic control. No records are easily available to permit estimates of money savings in general.

Repair, Parts and Servicing

To the enquiry as to who is responsible for instrument maintenance, replies disclosed that in most cases it is the instrument engineer. Where no instrument engineer is employed, or if he is absent, the plant engineer, or the control engineer or superintendent, is responsible.

Instruments are almost entirely purchased outright. One large pulp and newsprint mill rents on a very small scale, while others only rent temporarily for experimentation.

To the question "Do you carry complete replacements or repair parts", replies varied considerably. There is no indication that plants in remote locations tend to carry a larger stock of replacements and repairs than those closer to the sources of supply. Larger plants generally carry mostly repair parts in stock, and get the most necessary replacement units wherever possible. A few companies with several plants carry complete spare units in stock when possible or at least for the ones subject to frequent failure.

Servicing, replacing, repairing and calibration of instruments appears to be done predominantly by the plant staffs. This, of course, applies to minor servicing. Major jobs are customarily sent out to the maker for service. Even some larger papermills do their own servicing and replacements entirely, with exception of refilling of their thermometer bulbs.

The Instrument Crew

The size of the servicing crew varies from one instrument engineer with a head tradesman, five qualified mechanics and two to four apprentices, in the case of a large modern mill with many controls and measuring devices, to an instrument foreman and four men, assisted, when necessary, by electrical, mechanical or pipefitting crews, in the case of a smaller plant.

One pulp and paper producer with several mills, who has doubled his investment in instruments in the last five years, gives a 'rule-of-thumb' for servicing larger plants as "One man per each 250 units", which, in his case, works out at 1 foreman and a 5-man crew and shop facilities costing from $1,000 to $2,000, for each mill. The maximum number of instruments taken care of by one man as determined by a CPPA survey is 600, while the minimum number is 63. The average number of instruments per serviceman as recommended by ISA is 200 units.

Capital and Upkeep Costs

Initial cost of instruments, exclusive of installation, is estimated by a company with several mills at from 4 to 6 per cent of *total* capital outlay for a paper mill; 2 to 3 per cent for pulping; 6 to 8 per cent for bleaching; 2 to 5 per cent for steam, and overall 1 to 5 per cent.

One comparatively small but almost fully automatic plant 'guesstimated' its overall investment in instruments amounted to close to $1 million. Another company with two large mills gave capital cost for instruments and meters at $10,000 and for combustion controls at $8,000 in each plant. Another medium-sized "Kraft Mill" estimated its investment in instruments at close to $360,000, while still another company with two large pulp and paper mills reported capital cost of instruments including installation at between $1.5 and $2.25 million.

Upkeep cost on instruments seems to average $20 per unit annually for service and about $120 per unit for overall cost including replacements, which would in the case of some large mills run into very high figures. One large pulp and paper mill estimates its total cost for upkeep runs at least to $50,000 per year which, considering its capacity, appears to be moderate. Another large western mill's upkeep averages over $100,000.

Annual instrument cost for one large mill including servicing and maintenance but excluding new installations, runs around $13,000 for material and $23,000 for labour. Another medium size plant with up-to-date instrumentation spends $10,000 yearly on repair parts and $50,000 on labour; while a smaller mill reported $10,000 per year for replacements *and* labour. Still another company, with two large mills, reports cost of annual upkeep at $20,000 for instruments and $60,000 for maintenance.

Average Write-Off Two Years

Time required to recover initial cost of instrumentation varies widely, according to the process. A possible general average from a small number of replies appears to be around two years. Some companies replying stated all their instruments are justified on capital cost recovery within two years or less. Certain instruments are purchased for quality control only, which is, at times, an intangible value.

Commenting on the percentage reduction in manufacturing costs of various products through instrumentation, some companies replied that their plants would not be operational without instrumentation, and consequently no comparison with manual operation was possible.

One large manufacturer of pulp, paper and allied products pointed out that most instrumentation serves as quality control, or to increase operating efficiency as compared to manual labor. He estimated production per man-hour had increased and quality control had improved to the extent that, in general, instrumentation would save its value in one or two years. This, however, did not apply to measuring controls.

Who Specifies and Purchases Instruments?

Specifications are drawn up for instruments in processing plants and their installation in almost all cases by company's own staff of engineers. Consultants are frequently called in for advice, design and specifications on special installations, or in the case of new processes in the manufacturing plant, though even here some plants cling to the practice of relying on the advice of vendors.

There is no set procedure for purchasing instruments. Sometimes purchasing is done through the local purchasing department on specifications drawn up by the instrument engineer. In other cases specifications are drafted by the control dept. and orders are placed by the instrument department through the Company's purchasing agent. In the majority of cases purchasing is done through the central purchasing department.

Summing Up

Replies to a request for general comments on the importance of control and instrumentation in present operations, and for suggestions as to future trends, brought out some interesting opinions. The opinion of some companies appears to be that operation at the efficiencies required in order to stay competitive is impossible today without instrumentation.

It was generally felt that control and instrumentation could be increased in present operations to better the quality of products. Processes are being continually checked for further applications of instrumentation where these can improve production and quality. One reply stated . . . "without automatic controls in our big boilers it would be impossible to maintain efficient operation under sudden load changes." Other replies pointed out that more and more controls are being used in every department of the pulp and paper industry. Few controls displace men, but only relieve routine. "It is doubtful if the quality control or safety precautions would be effective if automatic controls were not employed," said the technical director of a large paper mill. "Most phases of the pulp and paper making industry will continue to require the operator's mind to direct and temper the control system, so as to produce the desired product. Thus a '*fully* automatic plant' is not in the foreseeable future. The processes are not yet predictable enough from scientific data for complete automation."

The Technical Superintendent of a western mill made these comments: "Future trends seem to be for more transmitter - receiver installations which is necessary for miniature instrumentation. Electrical and electronic instruments are competing well with pneumatic types. The trend to digital readout is not noticed in Pulp and Paper, but possibly will be soon. The general trend of instrumentation and automation would seem to require the training and development of a class of mechanic or technician able to service electronics, hydraulics and pneumatics."

Better Planning Needed As Well as Automation

Reasons for automation in the past in mills producing writing and printing papers shipped in sheet or roll form have been to produce more per time unit; to obtain greater uniformity of product; to reduce cost of product; and to make the product available to many.

The automation program must correct a maximum number of defects where they originate. It must make defects in the paper reel visible to the cutter through better signals. It must improve early identification of the best tonnage by sorting or converting for automated flow on end of the paper machine to finished flow. It must sidetrack off-standard tonnage for inspection.

Today automation is established practice in roll-rewinding controls, sheet cutting, loading, laying off sheets, counting, trimmers with automatic size of cut, setting, ream wrapping and carton packaging machines. Each of these operations require above average intelligence, which in turn requires a higher-paid worker. The jack-of-all trades 'millwright' of the past is fast disappearing, and being replaced by specialized maintenance crews.

Changes in planning and layout are needed too. Each delay represents extra placing and pick-up of tonnage representing man power and or machine energy. Good planning and clear directives are essential once such automation equipment is installed. How far a mill goes with future automation will still depend greatly on the future requirements of its customers, and on improvements in automation attained by the converters and the printers.

Organization of An Instrument Department

The rapid growth of instrumentation has, no doubt, induced pulp and paper mills, like many other industries, to organize a specified group to look after automatic control equipment. Most mills have found it expedient to combine maintenance with other functions such as trying out of experimental or temporary installations and carrying out a testing service.

This instrument group must be a

separate entity, with the chain of authority defined so as to conform with provincial laws and Union jurisdiction. It will be under supervisory authority, which is customarily shared 50/50 between control superintendent and the plant engineer or Engineering Dept., dependent on management opinion. Work of this instrument section extends across mill-department boundaries. It must never become an appendage to any of the processing groups, but must be a department with equal status to any other department in the mill. It must supervise new and modified circuits as well as attending to routine operation and servicing. The group needs a place to work, tools and machinery, test apparatus, spare parts, and instruction files and records. A rule-of-thumb for the workshop area including office space would be an average of 50 square feet per instrument unit, but not more than a maximum of 100 sq. ft.

Next under the control superintendent or plant engineer comes an instrument foreman. Under him come the technicians whose duties are to find faults, repair them, recalibrate, relocate, install, test and use instruments as instructed by the foreman. All these technicians are trained to handle certain common general duties.

Each technician in the group specializes as or in at least one of the following; process trouble shooting, analysis and start-up; electronic measuring and control; combustion control and boiler instruments; fluid dynamics, heat balances, etc; gas and chemical analysis; mechanical repairs; calculating machines; watchmaking, and lathe operation.

Equipment

Providing a basic tool kit for each man will pay off. An enterprising workman will add his own tools to the kit. A small precision lathe is a 'must'. Equipment should include a drill-press, bench guider, oxyacetylene equipment and a pressure-calibration bench, dead-weight testers, manometers, and thermometers for calibration standards. The watchmaker needs all the tools of his trade and a workbench for his job. An engraving machine is useful also for cutting name plates.

The office accommodation may be an area set off or partitioned from the shop area or it may be only 'desk room' with file cabinets and a library shelf containing instrument catalogues and text books. Files should include specifications and histories of each instrument from which to establish a maintenance schedule and to requisition spare parts. Cardex filing systems are found to be most satisfactory.

Instruments are getting more rugged and more reliable every day, and are taking on more difficult tasks and becoming more involved. To meet this change instrument departments must expect their duties to be upgraded. Education is listed as the top qualification for apprentices, followed by aptitude, initiative and tact in that order. The technician starting out today should have at least a senior matriculation education. The head of an instrument department who is not an engineer will be overlooked in promotion if he does not develop technically.

The more remote the mill, the better the training program for instrument technicians should be. Skilled men are in short supply and personnel have to be recruited and trained. About a third of Canadian pulp and paper mills have regular training programs, and a few have study periods on Company time for apprentices. An apprentice should be trained to read instruments and to know their limitations. Each should be taught how to switch instruments from automatic to manual control, and not to touch anything except set points.

About a third of Canadian pulp and paper mills have scheduled maintenance of instruments, while in another third of them maintenance is on a demand basis only.

Current Sulphite Mill Instrumentation*

Questionnaires were sent out in 1957 by Bowaters Newfoundland Pulp and Paper mills to some 20 Canadian pulp and paper mills across Canada, as reported in a recent issue of "The Canadian Pulp and Paper Magazine". Answers gave an indication of the extent to which instrumentation was being utilized at that time. Questions dealt mainly with types of instruments and controls used in various applications, and the problems encountered.

Only four of the mills reporting instrumentation in the melting of raw sulphur use a modified on-off or actually limit control. Biggest obstacle with types other than a temperature bulb in the molten sulphur tank is excessively high maintenance, and the constant attention required.

Of all mills questioned, the majority use a Glen Falls type of rotary burner and automatic burner-level control seems almost standard. Most mills have some form of measurement or control of SO_2. Most mills had found that by using suitable condensers on the sample line, the problems of moisture entrained in the gas could be handled fairly well.

From replies to this questionnaire it was gathered there was as yet no entirely satisfactory method of measuring acid or Baumé density. Only two mills had a record of this important variable, and they experienced high maintenance, which made it almost impossible to keep the unit in service.

On storage tanks, recovery towers and accumulators most mills record, and in some cases control, pressure, level and temperature. On pressure and livel measurements some form of liquid purge or sealing fluid is needed.

In digester operation the main variable that determines the rate of cooking is temperature, and this is regulated by controlling the flow of steam manually or automatically. Seven of the 20 mills reporting used manual cooking control, while the balance used automatic control with either steam flow or temperature program-cams being used. The desired steam flow or temperature is plotted against time in the form of a cam, and the controller then automatically controls the steam valve to give the desired values.

Fifteen of the 20 mills questioned used acid circulation systems either wholly or partially. Control of digester relief was fairly standard, fifteen using pressure set-point type of control. On the question of measuring digester level half the mills recorded it and the other half merely observed it with gauge glasses. Maintenance was fairly high for measurement devices with those who measure it the DP cell seems the most widely accepted instrument.

One very evident feature of the replies was the similarity of installations throughout the mills questioned. Practically all mills were found to be on the same general level of instrumentation, with few showing any great deviation from the average. This indicated there had not been as much development here in recent years as in some other industries or even in other sections of the paper industry. The survey showed conclusively that the major problem was one of maintenance, keeping instruments operative in an extremely corrosive envir-

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*Reproduced in part from a paper presented before the Technical Section, Canadian Pulp and Paper Association, by permission of the Technical Section CPPA.

INTERNATIONAL NEWS

SWEDEN

NEW RADAR SIGHTS. The 8000-ton Swedish cruiser *Göta Lejon* is said to be the first naval vessel in the world to be equipped with radar sights of a novel 'thinking' type, which will considerably increase the efficiency of her AA artillery. Part of an almost completely automated firing system, the radar sights operate on a signal, giving the horizontal attitude of an attacking aircraft, received from the ship's reconnaissance radar, which covers a wide horizontal and vertical field. The sight then automatically fixes the vertical position of the aircraft and locks the guns on the target, at the same time calculating the necessary lead. One or more guns can be controlled simultaneously, and are fired manually from the fire-control centre. The equipment, designed and made by the Dutch electronics firm Hollandsche Signaal Apparaten, is to be introduced on most destroyers.

LARGEST HEAT EXCHANGERS. The Alfa-Laval Group reports an order for several plate heat exchangers of an entirely new design, claimed to be the largest of their kind in the world, for a new aluminium producing plant in Guinea. The order, worth over $400,000, includes equipment for a total heat exchange area of some 54,000 square feet; heat savings are estimated at about $10,000 a day. The exchangers are used for cooling hot process solutions and heating and concentrating the cold used aluminium salt solutions. The plant, to be the largest aluminium producer in the world, is being financed by American, British, French and Swiss capital, and was designed by French engineers. The former French territory has large deposits of high-grade bauxite.

UNITED KINGDOM

RUSSIAN TECHNICAL TRANSLATIONS. Recent Soviet achievements in many fields of science and technology have aroused great interest in other countries, but because of the language barrier few engineers outside the U.S.S.R. have been able to follow these developments at first hand. Now, however, the Production and Engineering Research Association, with the support of the Department of Scientific and Industrial Research, is making complete translations of *Stanki i Instrument*, one of Russia's leading technical journals. The English version will be published monthly from January 1959 under the title *Machines and Tooling*. This will cover research and development over a wide field of production as well as improvements in equipment and methods based on operating experience. Subjects include: tool design; ceramic tools; automation; induction heating; hydraulic mechanisms; machine controls; metal fabricating and finishing techniques; production in plastics; and many others.

THERMONUCLEAR CONVENTION. The Institution of Electrical Engineers has arranged for a Convention on Thermonuclear Processes to take place in London on 29th and 30th April 1959. The proceedings, held in conjunction with The British Nuclear Energy Conference, will be opened by Sir John Cockcroft, of the U.K. Atomic Energy Authority. Papers will be presented and discussed, and Sir George Thomson, Master of Corpus Christi College, Cambridge, will deliver a closing contribution. Subjects will include basic principles of thermonuclear processes, British work in the field, the possibilities of direct conversion from nuclear to electrical energy, and reviews of related work in the U.S.A. and U.S.S.R. Further particulars from the Secretary of the Institution.

AVIATION NEWS. Rolls-Royce jet and turbojet engines are to be made under licence in Germany by the M.A.N. engineering firm in Munich, to power civil and military aircraft still on the drawing boards in the reorganized Messerschmitt and Heinkel factories . . . The three 140-ton *Princess* flying boats (the world's largest), 'cocooned' since 1953, may be used by a new British company on a commercial passenger service between Britain, Rio de Janeiro, the Canadian Great Lakes, and a point in the U.S. . . . The balloon *Small World*, in which four persons recently attempted a crossing of the Atlantic from the Canary Islands to South America, had a 53,500 cu. ft. envelope of Terylene double-proofed with neoprene and contained in a hemp cord net made by a Ministry of Supply technician at Cardington.

UNITED STATES

HIGH-SPEED WIND TUNNELS. Conventional aerodynamic tunnels in which many problems have been solved, notably in the laboratories of the National Advisory Committee for Aeronautics (NACA), have been made obsolete by the advent of jet and rocket propulsion. The following are some of the recent installations in the U.S. which operate in speed ranges of the order of 2,500, 3,750, 15,000, and 32,000 m.p.h. North American Aviation Inc. has built the first privately financed 'trisonic' tunnel at Los Angeles, Calif. This single installation can be operated at subsonic, transonic, and supersonic speeds. The height of the actual 44-ft. long test chamber can be increased by a hydraulic mechanism from 3.5 ft. (supersonic range) to 6 ft. (subsonic). Operating air is stored at high pressure in eight steel spheres. In addition to the usual measuring equipment, the tunnel is fitted with cameras and data processing equipment. The Convair Division of General Dynamics Corp. has a tunnel at San Diego, Calif., which can operate from Mach 0.5 to Mach 5. Working on an intermittent cycle, power from an 8,000 h.p. motor is used to produce effects equivalent to the use of a 150,000 h.p. motor in a conventional tunnel. The stored energy is released for periods of up to two minutes, with an average of 30 seconds. Air is compressed to 85,000 psi. in six reservoirs with a total capacity of 116,500 cu. ft. The Lockheed Missile Systems Division tunnel at Sunnydale, Calif., for tests on the *Polaris* missile, can reach speeds of 15,000 m.p.h. and temperatures of 10,000°C. in a test chamber some 44 ft. long, 2 ft. high, and 6 ft. wide. An electrical charge of 20 million kw. is used to raise the temperature of a small quantity of compressed air at one end of the tunnel to 10,000°C. and the pressure to 4.9 million psi. The duration of the test is kept to 1/25th sec. to avoid melting the walls of the tunnel. To study the effects of placing a space vehicle in orbit and conditions of re-entry into the earth's atmosphere, another installation, Hotshot II, uses an electrical discharge to produce the effects of speeds up to 32,000 m.p.h.

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past 50 years. The properly equipped aeroplane is a useful tool in today's world.

FABRICATION TECHNIQUES

by W. H. Riggs, Vice President Manufacturing, Avro Aircraft Ltd.

THE PAST FIFTY YEARS of aviation in Canada have brought about many changes in manufacturing. When the *Silver Dart* flew on 23 February, 1909, aviation in Canada consisted of a few ingenious individuals across the country who, in their backyards and sheds, were trying to invent and build machines of various kinds, that they hoped would fly. Their techniques were the "do it yourself" kind required to produce the wire, wood, and fabric contraptions of the day.

From these beginnings, an industry developed. Laminated wood sections replaced the solid wood members, and assembly fixtures were introduced to hold laminations during glueing operations. Plywood replaced fabric coverings, and steam pressure chambers were used to form wood panels. Metal tubular frames followed, requiring welding and control of welding processes.

Though wood was used extensively even during World War II on such aircraft as the *Mosquito* and *Cornell*, it was the introduction of the all-metal aeroplane that resulted in the most outstanding fabrication developments.

Light alloy materials were introduced, such as aluminum, with steel castings and forgings for greater strength at critical points. The machine and sheet metal shop replaced what had been mainly a carpentry operation. Heat-treat furnaces and process tanks changed the condition of these new alloys to permit forming operations, and provided a corrosion-resistant surface to the metals.

The quantities of aircraft required during the war years brought about new techniques which were aimed at quantity production. Routing processes were developed using a rotating cutting tool to cut sheet metal to the shape of a template. The rubber press was introduced to form these parts on form tools. Rubber presses of up to 15,000 tons capacity (Fig. 16) are at present in use in the industry. Stretch forming presses were developed to stretch and form sheets of material over large form blocks.

Methods of assembling these parts were improved with the introduction of hand-operated power tools. These included rivet guns and drills with portable heads to permit access to difficult work areas.

Because an aeroplane has many areas that restrict the number of men who can work at one time, extensive use of component assembly jigs was introduced. The structure was broken down into sections and these sections sub-divided into sub-assemblies. This permitted wider distribution of the labour force, and provided interchangeability of the various components. This breaking down of the work into specialized jobs has brought about the use of some six hundred classifications or trades within the industry today.

Rapid developments of the post-war supersonic age emphasized new problems in fabrication techniques. The problem was to reduce fabrication and development time in order to put the aircraft into service use in the shortest possible time. A reference to the production of Canada's Avro CF100 and Avro *Arrow* interceptors will illustrate this change of approach.

In the early development of the CF100, a number of prototype or development aircraft were built using many hand made parts, and parts made with tooling of limited production life. As these aircraft were going through their development stage, it was necessary to enter into a production tooling program before delivery of service aeroplanes. This delay was now prohibitive and, to overcome the problem, stable production tools and assembly fixtures were introduced at the start of the development program of the Avro *Arrow*.

Other improved techniques included the use of glass cloth on which parts were drawn to scale, providing a direct transfer of tooling and part dimensions to the shop. Full-scale master models of components provided an accurate reference for forming parts affecting critical outside surfaces. Metal to metal bonding and honey-comb construction were introduced into the design of the aircraft. This process is done in the autoclave (Fig. 17) where parts and bonded assemblies are cured under pressure and heat after application of adhesive.

Present supersonic aircraft require numerous heavy machined parts. This introduced heavy machining techniques such as skin milling (Fig. 18), where large wing skins are milled from solid billets of metal, eliminating design and assembly of numerous detail parts. Chemical milling is now under development where metal is reduced to shape by chemical action, replacing some machining operations. Electronic and tape operated lathes and mills that are presently being developed will make the machining operation a completely automatic process and will eliminate the requirement for much of the present-day tooling.

Another important development has been the need for control over the flow of thousands of parts through manufacturing and assembly stages. Canada's Avro *Arrow* has 38,000 parts, all of which must meet a predetermined schedule of production in order that assembly of the finished aircraft will not be interrupted. This control must also be exercised over 'bought-out' equipment such as air-conditioning, electronic and armament installations. The scope of this control can be further realized when we consider that over 650 companies and thousands of outside workers share in the production of today's supersonic aircraft, producing parts and assemblies to meet one over-all schedule.

COMBUSTION CONTROL

(Continued from page 69)

search, designs, products, and publications of our great friend and neighbor to the south.

This condition is of course not confined to the field of instrumentation but is widespread in light manufacturing, both mechanical and electrical. In the present state of Canadian markets, those who can should be planning new scope for the inventiveness of engineers at home, wider latitude for manufacturing in Canada, and support of university training that will inspire initiative and development.

Those engaged in engineering in all its phases are accustomed to understanding cause and effect, adding one and one to make exactly two, and assessing what is true. They tend by nature and habit to honesty, and are well qualified to exercise these talents beyond their profession, in the world around them.

They have become increasingly aware of the significance of what their effect has been and can be in raising the level of human welfare. There has been a trend, shared by instrument personnel, toward increased participation and leadership in affairs on community, provincial, national, and international levels.

Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

The Year 1958 Reviewed

Ontario Hydro

New stations and additions to existing plants, representing more than 800,000 kilowatts of capacity were placed in service by the Hydro-Electric Power Commission of Ontario in 1958. At year end, nine projects totalling 2.3 million kilowatts of capacity were under development.

Demand climbed above 5 million kilowatts for the first time. The Commission's total capacity reached 5.76 million kilowatts.

Capital construction expenditures were $200 million. St. Lawrence and Niagara river developments were the largest projects in the program.

Robert H. Saunders-St. Lawrence Powerhouse: 7 units placed in service, with nine more to come into service progressively in 1959; Ontario Hydro to receive 950,000 kw., at capital cost of $300 million.

Sir Adam Beck Niagara Generating Station No. 2: 2.2 million kw. now derived from Niagara River, with installation of 15th and 16th units.

Richard L. Hearn steam plant, Toronto: expansion continued; four units totaling 800,000 kw. are being added, with two units going into service in 1959. Ultimately, in 1960, capacity will be 1.2 million kw.

Lakeview thermal generating station: site west of Toronto is being prepared; installation designed for ultimate capacity of 1.8 million kw. at cost of $250 million; excavation to commence in 1959; two 300,000-kw. units to be in service by 1962. A second similar plant is planned for the Toronto-Hamilton area.

Northwestern Ontario: expansion in 1958; new hydro stations went into service at Whitedog Falls on the Winnipeg River and Caribou Falls on the English River.

Port Arthur: a 45,5000-kw. development at Silver Falls on Kaministikwia river is being built.

Thunder Bay coal fired plant at Fort William: construction started; initial capacity, 100,000 kw., at estimated cost of $26 million; power available in 1961; provision for enlargement to 1 million kw.

Red Rock Falls development on Mississagi river: preliminary construction in progress for completion in 1961.

Otter Rapids project on Abitibi River, near Kapuskasing: a start made on 131,000-kw. development; power scheduled for fall of 1961. Fifth unit of Abitibi Canyon station to be completed early in 1959, adding 45,000 kw.

Extra High Voltage Transmission: studies under way to determine economy of transmitting power from potential northeastern hydro sites capable of 1.8 million kw.

Nuclear power: Construction resumed in July on Nuclear Power Demonstration plant at Des Joachims, Ont.; to be in operation in 1961. Ontario Hydro is also involved in design and development phase of full-scale nuclear plant. First phase may be in 200,000-kw. range.

Frequency Standardization: ten-year program close to completion.

Rural expansion: 920 miles of line added.

Public Works, 1958

The activities of the Department of Public Works continue to expand in dollar value and in variety of projects, Deputy Minister H A. Young reported to the Canadian Construction Association meeting in January. Estimates for the current fiscal year are of the order of $240 million, and the indication is that expenditure will exceed 90 per cent of this. The Department also spent some $37 million on behalf of other government departments.

Of this latter category the Deputy Minister mentioned these: construction in N.W.T. and the Yukon, buildings and highways, largely projects for the Dept. of Northern Affairs and National Resources; a road program in national parks for the same department; roads to resources; marine work for Transport and National Defence Departments; work in the national parks sections of the Trans Canada Highway.

Housing comes under Public Works through Central Mortgage and Housing Corp. More than half the number of housing starts of all kinds during 1958 received Federal aid of some sort. Sixteen cities have undertaken redevelopment and renewal studies with assistance under the National Housing Act.

Winter construction is a concern of the Department. Besides programming maintenance and interior work on buildings started earlier, the Department scheduled 375 small harbour and river projects for the current winter. It continued work on as many marine projects as possible and is carrying out building of some 65 small post offices.

The Department is using models in studying problems of harbour development. The first major one related to Port Aux Basque and there are other model studies going on. The testing laboratory of the Department is moving into a new building.

An inter-departmental investigation of special interest is studying harbour developments extending from the Head-of-the-Lakes to Father Point. A similar study preceded the current harbour development at St. John's, Nfld., where the final cost will be some $12 million.

A study being carried on will report on the feasibility of a causeway across Northumberland Strait, between Prince Edward Island and New Brunswick. Another proposal under study is development of a new Arctic town at Frobisher Bay for the Department of Northern Affairs.

Deputy Minister Young said that activities of the coming year could not then be forecast. But the intention was, he said: to maintain the tempo, to pursue the program of federal buildings in small centres, to continue the highway program in Northern Canada and to expand the program of harbour improvements for navigation.

By means of a new 23-mile railway extension from Nimpkish, Vancouver Island, Canadian Forest Products Ltd., can haul logs to Beaver Cove. From there the logs are towed in booms to the company's processing plant at Vancouver. One of the nine major bridges on the new extension is shown above.

What Goes On

Iron Ore Outlook

An improvement in demand for iron ore is predicted for 1959 by M. S. Fotheringham, president of Steep Rock Iron Mines Limited, though iron ore is not at present in short supply.

Preservation and expansion of export markets is the industry's problem, Mr. Fotheringham says, with competition becoming increasingly keen for both the American and European markets. He estimates Canadian output could reach 96 million tons, 70 million to go to the United States, 16 million tons overseas, and 10 million consumed in Canada.

New Brunswick Prospect

The New Brunswick department of industry and development has forecast business in 1959. In the separate industries these trends are predicted:
Food industries: an increase in sales by 3 to 7 per cent;
Pulp and Paper: domestic sales higher by 3 to 10 per cent; exports increasing, or equaling those of 1958;
Metal mining: improvement in domestic sales by from 3 to 10 per cent and in export by 10 per cent; new interest in N.B. deposits;
Construction: sales to equal those of 1958, with housing starting slowly;
Merchandising: a gain in sales and improvement in profit.

Exploration in N.W.T.

Permits to explore more than a million and a half acres of the North-West Territories for oil and gas were acquired recently by six major oil companies.

Successful tenderers were Texaco Exploration Company, Champlain Oil and Refining Company, Canadian Husky Oil Limited, Imperial Oil Limited, Sun Oil Company, Mobil Oil of Canada Limited. The permit area runs along the Mackenzie River south-east to north-west some thirty miles each side of Norman Wells.

This brings to 76.5 million acres the area of northern Canada now under oil and gas permits.

Anniversary at Cornwall, Ont.

The Howard Smith Paper Mills Limited celebrated the 75th anniversary of its Cornwall division in November, 1958.

In 1883 the first sheet of paper was made; production of paper in 1903 was 3,000 tons; estimated production for 1963 is 112,000 tons.

In 1958 a new, larger soda recovery plant went into operation, and five major projects were announced, including a sixth paper machine.

Shawinigan Water and Power

All six units of the Beaumont power development will be in operation in 1959, Shawinigan Water and Power Company reported to its shareholders in November.

The 246,200-kw development on the St. Maurice River in Quebec was opened in September, 1958, with construction three months ahead of schedule and two generating units ready for regular operation.

St. Lawrence Seaway

At the end of 1958, construction of works under the St. Lawrence Seaway Authority jurisdiction had progressed to a stage which assures that all channels, locks and ancillary structures will be available to shipping at the opening of navigation next spring, subject, in part, to a restricted depth of twenty-four and one half feet until June 1, when the specified minimum depth of twenty-seven feet will be available throughout.

Completion of production and clean-up dredging to full depth and width in some channels was retarded by the early arrival of winter and by a shortage of dredging equipment. Production dredging remains to be done in these locations:
Turning basin at Montreal harbour: This work now expected to be completed at the end of the 1959 season. Until then ships may turn at the Longue Point Anchorage.
South Cornwall channel: Completion is scheduled for October 31, 1959. However, a safe channel of 450 ft. width and 27 ft. depth will be available at the opening of navigation.
North Cornwall channel: The use of this channel is not required in 1959. Work is scheduled for completion in late summer 1960.
Thousand Islands Section: Completion scheduled for July 1, 1959. Except for a half-mile stretch at Brockville Narrows which has been in use at width of 280 ft. during past years, a safe channel of 450 ft. width and 27 ft. depth will be available at opening of navigation.

Twenty-seven footh depth will be available in all channels after June 1 and, prior to that date, in all channels except the following where these conditions will govern:
Lake St. Louis: a 24½ ft. minimum depth at lower end of lake.
Lake St. Francis: a 24½ ft. minimum depth at a point ten miles below Cornwall.
Upper approach to Iroquois Lock: a 25½ ft. minimum depth.
Welland Ship Canal: navigation will be restricted to half channel widths in two short reaches. Available depth will be 27 ft.

Applied Physics at the Ontario Research Foundation

Dr. B. W. Schumacher, head of Department of Physics

The Ontario Research Foundation has recently enlarged considerably the staff and facilities for work in physics. A new Department of Physics is under the direction of Dr. B. W. Schumacher.

The new department is staffed and equipped so that, with the help of the longer established departments in the Foundation, it will be able to serve industry by (1) the study of materials and processes using modern physical methods; (2) the development of new instruments and techniques to meet the ever-changing needs of industry, and (3) the study of physical phenomena which will ultimately form a basis for new applications.

In the study of materials the physicist often joins forces with the chemist and metallurgist; in the development of instruments he enters the field of engineering. However, the approach of a physicist differs often from the approach of the other scientists. It may be more fundamental and therefore yield complementary information of value.

Some of the facilities at the Ontario Research Foundation laboratories are described below. A few of the characteristic features of physical methods are given with emphasis on the kind of information derived.

An electron microscope (Type Elmiskop I by Siemens) is the most recent addition. This instrument is installed in a room which is dust free and free of static electric charges. Its purpose is to get pictures of small objects or the details of surfaces which are beyond the reach of the optical microscope. These pictures reveal details of small objects beyond the wavelength of light. They convey, however, no information about the internal structure of these objects.

The resolution of the Elmiskop I is better than 12°AU, and due to its high beam voltage of 100 kev. relatively thick objects may be examined. For instance, some metal films may be observed directly, dispensing with the usual replica technique.

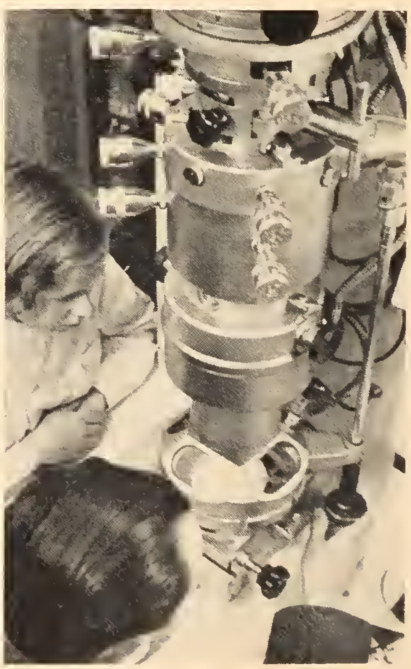
The Elmiskop I includes an *Electron Diffraction Camera*. The diffraction picture — whether taken by electrons, X-rays, or light — tells something about the structure of the diffracting substance although the elementary units of that structure are too small to be directly visible. But a limit is reached again, and one has to resort to another method if direct information as to chemical composition is required. To overcome this limitation a new method for getting an additional chemical analysis with an electron probe is under development at the Ontario Research Foundation.

Diffraction techniques do not give information about the elementary units of periodic structures like crystal lattices; they give only the average or ideal structure. Nevertheless, with all the refinements of the method, a surprising number of statements about these structures can be made.

X-ray Diffraction

The older method of X-ray diffraction with all its refinements is constantly employed. Various cameras suitable for any kind of crystal analysis and a recording diffractometer with Geiger counter are used. The X-ray laboratory is under the supervision of Dr. Ursula Martius. X-ray diffraction basically gives information as to the crystal structure of elements and compounds. Many of these structures are well known to-day and tabulated in a reference file issued by the ASTM. One of the very frequent applications of X-ray diffraction analysis is the indentification of an unknown compound by comparing its structure which is characteristic, like a fingerprint, with the structures on file. This kind of identification always yields the compound, i.e. it shows whether Fe, FeO, Fe_2O_3 or $FeSO_4$ are present. It might be called a molecular chemical analysis. Furthermore, X-ray techniques can be used to determine grain orientations, grain sizes, and of course unknown crystal structures. However, X-ray diffraction does not provide information as to shape, surface appearance, etc.

Electron microscope



In addition to the diffraction analysis, the available instrumentation is capable of *elementary* chemical analyses using X-ray fluorescence. In this analysis one observes the characteristic spectrum emitted from each of the chemical elements of a sample if bombarded by other, harder X-rays. This is similar to and complements optical spectroscopy or, for instance, the analysis by means of an ultra-violet lamp. The X-ray fluorescence is limited in its applications to elements with atomic number of 13 (Aluminum) or higher and to specimens of a fairly large size, say ¼ inch square. The Ontario Research Foundation is at present actively developing a method for covering the lower number elements also, by means of a microprobe less than one mil in diameter.

The Foundation does not now make radiographic pictures of large objects. However, microradiographs are made and have been used in several applications, for instance, locating precipitations of cobalt in a metallographic specimen and in the analysis of ores and minerals.

The electron microscope and X-ray laboratory is supplemented by a most complete *microscopy laboratory* which has been described previously.* It is based on standard instrumentation, and staffed by specialists. Using a standard colour photometer one of the staff recently showed a novel way of measuring the thickness of surface films on metals. Surface studies by the Tolansky interferometer method have led to valuable industrial information. All these laboratories are supplemented by excellent photographic facilities.

Infrared Spectroanalysis

The infrared spectrophotometer and laboratory, directed by Miss E. M. Kirby was recently expanded by a double-beam Perkin-Elmer spectrometer.

Infrared spectroanalysis provides molecular chemical analysis. The specimen, in this case, does not need to be present in the form of a crystalline substance. It can be in solution, or in a solid or gaseous form. The instruments determine some of the vibrational or rotational energy levels of the molecules. The related "absorption spectrum" can be used to identify the molecules present, or structural units in the molecules, even differentiating between isomers. This technique is especially useful in the analysis of organic substances but is not restricted to them.

In addition to the infrared spectrometer there are instruments for absorption spectroscopy in the ultraviolet and visible range of the spectrum, e.g. a Carry double-beam spectrophotometer and instruments for flame photometry.

It is not easy to draw a line where physical methods stop. The number of inspection methods is almost unlimited, since every physical constant that can be measured can be used for analytical purposes as well; for example thermal expansion, heat of solution, refractive index, etc. There is the relatively new method of vapour phase chromatography which differs basically from those methods listed above.

Vapour Phase Chromatography

Equipment for vapour phase chromatography is installed in the air pollution laboratory under the direction of Charles Newbury. The instruments provide an analysis by separation. The compounds in a mixture are separated due to their vapours requiring different lengths of time to be carried through an absorption column by a stream of dry gas, usually helium. The arrival of each component at the outlet is noted by a detector and recorder.

The unit has a separation efficiency equivalent to a distillation column of at least 4,000 theoretical plates, and recent developments promise an increase in this number to 100,000 using a sample as small as 10^{-8} grams. Consequently, this instrument is used to separate close boiling mixtures such as isomers. Not only will vapour phase chromatography give analysis of organic liquids, but it can determine the presence of natural gas in soil samples, indicating pipe leakage, or the percentages of hydrogen, oxygen and carbon-monoxide in 0.1 milli-litre of gas collected in the degassing of a steel sample.

Ontario Research Foundation will from time to time install new instrumentation to meet new problems as they arise. Important as these instruments are, they do not overlook the supreme importance of imagination, skill and experience of the scientific staff.

*A model Metalographic Laboratory, Majka, S.J. **Can. Metals** 19, No. 3: 54-58, (pt.1); No. 4: 56-63, (pt.2). 1956.

Hydro-Electric Progress in Canada, 1958

A maximum record was established in Canada in 1958 in the amount of new hydro-electric generating capacity brought into service in one year.

This is reported in the bulletin (No. 2625) published January 2 by the Water Resources Branch of the Department of Northern Affairs and National Resources, Ottawa.

The net total of new capacity installed was 2,485,040 hp. The previous high record was 1,758,450 hp. installed in 1954.

Ontario's total of new capacity was 1,301,800, the highest of the provinces; total for Quebec was 900,000 hp. The total installed capacity of water power plants in Canada is now figured at 22,376,048 hp.

The Bulletin is free of charge, available from the director, Water Resources Branch.

McMaster University Engineering Faculty

Progress is reported on several goals of McMaster University, Hamilton, Ont. There are students in the first two years of four-year degree programs in chemical, electrical, mechanical and metallurgical engineering, and engineering physics. First year of the civil engineering program commences in 1959. (*Engineering Journal*, Sept. 1958, Page 107).

There were eight members of the academic staff on campus by September, 1958; it is hoped to add eight more in 1959. Challenging positions are therefore open in all the named branches of engineering. Office and research space will be ready for occupancy in April, 1959. A personal interest in engineering research is a requirement, because a graduate research program is being developed.

Construction of the new Engineering building is proceeding well, for occupancy April 1, 1959.

Laboratory equipment is being purchased. Equipment already procured includes a Bendix digital computer, nuclear magnetic and electron spin resonance equipment, complete fluid mechanics laboratory, photomicrographic equipment and metallography laboratory. A one-megawatt nuclear reactor will commence operation in April. Associated with this there will be a single crystal neutron diffractometer. In chemical engineering, facilities make possible long range programs and mass transfer and radiation engineering. Electrical engineering has laboratories for servomechanisms and experiments on antennae. A new 50,000 lb. per hr. boiler can be used as an experimental facility. An adjacent steam turbine will allow realistic experiments on thermal power generation. A vacuum casting and melting laboratory will be the first of its kind in Canada.

Western Zone Technical Conference

October 2, 3, 1959, Banff, Alberta

On the recommendation of an E.I.C. Zone A. councillor's meeting held in Calgary, October 18, 1958, E.I.C. Headquarters has approved the holding of a Western Zone Technical Conference at the Banff School of Fine Arts on Friday and Saturday, October 2 and 3, 1959.

The main features of this conference are; a series of twelve technical papers with as many as possible dealing with the various economic and engineering aspects of Western Canadian Developments, a Forum on Irrigation and Drainage and a program for the ladies. Why not mark these dates on your calendar today and reserve a few days from your holidays so that you and Mrs. Engineer can attend the first Western Canadian Technical Conference?

Your help in obtaining suitable technical papers for the Conference is needed! You are invited to submit summaries of proposed papers to the Papers' Committee Chairman, Professor J. B. Mantle, c/o College of Engineering, University of Saskatchewan, Saskatoon, Sask. If you know of some engineer who could possibly contribute a paper you might inform the Papers Committee at an early date. The following deadlines are in effect:

May 15, 1959 — last date for submission of summaries and abstracts

July 1, 1959 — selection of papers complete

Sept. 15, 1959 — last date for submission of manuscripts.

W. A. SMITH, M.E.I.C.
General Chairman,
Western Technical Conference

Month to Month

News of the Institute and the Profession

COMMENT
CORRESPONDENCE
ELECTIONS
AND TRANSFERS

International Yard and Pound

Letter to the Editor

It would be appreciated if you would publish the enclosed announcement on the international yard and the international pound. The text is self-explanatory but it may be of interest to recall the following facts of local concern to Canada.

In 1951 "An Act Respecting Units of Length and Mass" (15 George VI, Chapter 31) defined the Canadian yard as 0.9144 metre, which is in exact agreement with the joint announcement. The same Act defined the Canadian pound as 0.45359243 kilogram which is slightly discrepant with the ratio being established for the international pound. This difference is insignificant in all measurements except those of the very highest precision. Nevertheless steps are being taken toward the amendment of the Canadian legislation to make the Canadian pound 0.45359237 kilogram and so legally equal to the international pound. The ratio 0.9144 was chosen because it leads to a yard which is approximately half-way between the present imperial (United Kingdom) yard and the U.S. yard. It has the added advantage of making one inch exactly equal to 2.54 centimeters. The ratio used in the Canadian legislation of 1951 to relate the Canadian pound to the international kilogram was the originally accepted ratio between the pound and the kilogram. Through the years the imperial (United Kingdom) pound and the U.S. pound have become very slightly different and the ratio used in the joint announcement makes the international pound approximately the average between the imperial pound and the U.S. pound.

L. E. Howlett,
Director, Division of Applied Physics,
National Research Council,
Ottawa, Canada.
29 December, 1958

Announcement on the International Yard and Pound

The directors of the following standards laboratories —

Applied Physics Division, National Research Council, Ottawa, Canada; Dominion Physical Laboratory, Lower Hutt, New Zealand; National Bureau of Standards, Washington, United States; National Physical Laboratory, Teddington, United Kingdom; National Physical Research Laboratory, Pretoria, South Africa; National Standards Laboratory, Sydney, Australia;

have discussed the existing differences between the values assigned to the yard and to the pound in different countries. To secure identical values for each of these units in precise measurements for science and technology, it has been agreed to adopt an international yard and an international pound having the following definitions:—

the international yard equals 0.9144 metre;

the international pound equals 0.45359237 kilograms.

It has also been agreed that, unless otherwise required, all non-metric calibrations carried out by the above laboratories for science and technology on and after July 1, 1959, will be made in terms of the international units as defined above or their multiples or submultiples.

CONFEDERATION — A Progress Report

At the January meeting of Council held in Toronto on the 31st, sound support was given to the report on Confederation presented by the Institute's committee. Councillors right across Canada from British Columbia to Newfoundland approved the following resolution:

"That this meeting of the Council of The Engineering Institute of Canada receives and now approves with appreciation the report of its Committee on Confederation (dated 6 Nov. 1958), instructs the general secretary to circulate all members of The Engineering Institute of Canada the ballot suggested in Dr. Tait's letter of January 9, 1959, in a form to be agreed upon by the Joint Committee and by Council, and requests its Committee on Confederation to continue its good work until the proposed Provisional Council is appointed."

The next step will be to send a report and a ballot to every corporate member of the Institute. This ballot, if favourable, will authorize Council, in collaboration with the Canadian Council, to set up a Provisional Council whose duty it will be to prepare all the final details for final presentation to the corporate membership for approval.

With the January meeting of Council, Confederation has taken a great step forward.

Scientific and Technical Manpower

The Department of Labour of Canada is at present conducting its annual survey of men and women in the scientific and technical fields. The purpose of this survey is to bring up to date the records of these professional people which have been maintained by the Department since 1942 and, as well, to provide information on Canada's manpower resources in these fields for use in research.

The survey is designed to help answer a number of important questions about scientific and technical professionals. What kind of jobs do these people move into on graduation and how does this picture change as they become older? What are the typical career patterns of those in the various engineering and scientific fields, both in terms of salaries received and types of work done? How many and what kinds of engineers and scientists eventually become research workers, teachers, administrators and executives? To what extent do they feel that their professional qualifications are actually used in different types of work?

The current survey is part of a program in which one-third of the people in scientific and technical professions will be approached each year. By these means, all those registered will be covered in a three-year period. Those surveyed each year are selected in a manner which permits the information secured to be used as a statistical sample representing the whole group.

This year's survey is the third conducted by the Department since the present program was inaugurated. In the previous two surveys, some 34,000 engineers, scientists, architects and veterinarians were mailed questionnaires. In 1959, it is planned to get in touch with an additional 23,000 professionals in scientific and technical fields.

For the 1958 survey, statistics were tabulated for a group of more than 11,000 respondents with regard to their 1957 earnings, employment and education. Engineers represented 55 per cent of those covered and natural scientists 38 per cent, the remainder being architects and veterinarians. For those with bachelor's degrees only, it was found that the median salaries for engineers ranged from $4,630 for 1957 graduates to $10,605 for those who graduated in the period from 1920-1924. For scientists, the range of median salaries was $4,400 for 1957 graduates to $8,450 for those who graduated prior to 1915. At all levels of experience, salaries paid by industry were higher than those paid by government or universities. Industry was also the largest employer, with 82 per cent of the engineers and 52 per cent of the scientists, followed by the federal government which employed 9 per cent of all engineers and 21 per cent of all scientists. The Department of Labour issued a preliminary release of these data last year and will be putting out a final report shortly.

There is a rapidly growing need in Canada for information of this sort and this survey provides the major source of such data. The Department of Labour's efforts, however, can only be of real value if the coverage of professions is extensive and information on registrants is maintained on an up to date basis.

The Institute fully endorses the maintenance of the national register of scientific and technical professions and the survey program being undertaken and asks that all members who have received the questionnaire form this year co-operate by giving prompt and accurate returns to the Department of Labour, Ottawa.

Annual General and Professional Meeting

The Engineering Institute of Canada

Royal York Hotel,

Toronto,

June 8-9-10, 1959

The Engineering Journal will have advance information about the meeting in every issue.

2nd SOUTHERN ONTARIO
of The Engineering

Sheraton Connaught
Saturday,

YOUR RESPONSE AND ENTHUSIASM

shown last year has demanded that a second Southern Ontario Regional Conference be held. It is again sponsored by the E.I.C., and all Southern Ontario E.I.C. and A.P.E.O. members and their ladies are urged to attend. Comprehensive plans have again been made by a special Hamilton Branch Conference Committee for your pleasure and convenience.

The program will be stimulating for both engineers and their ladies and will afford the opportunity to make many new friends. Seven E.I.C. branches are participating to ensure the success of this Conference. They are Toronto, Hamilton, Niagara Peninsula, Kitchener, London, Sarnia, and Border Cities.

11.00 a.m. MEZZANINE FLOOR — **REGISTRATION**
Advance registration forms and hotel accommodation forms will be mailed to all members.

12.15 p.m. CRYSTAL BALLROOM — **MEN'S NOON LUNCHEON**
Prior to and during the informal noon luncheon, delegates will have the opportunity to renew old friendships and make new acquaintances.

1.00 p.m. CRYSTAL BALLROOM — **PANEL DISCUSSION**

What's on the Horizon for John Smith, B.A.Sc., Class of '65?

L. S. LAUCHLAND, M.A.SC., M.E.I.C., P.ENG.,
Professor and Head of Department of Engineering Science, University of Western Ontario.

S. D. RENDALL, B.A.,
Superintendent of Secondary Education, Department of Education, Toronto.

L. D. DOUGAN, B.A.SC., P.ENG.,
Vice-President, Operations, Polymer Corporation Ltd., Sarnia.

MODERATOR

H. L. SHEPHERD, B.A.SC., M.E.I.C., P.ENG.,
Manager, Salary Administration and Personnel Development, Canadian Westinghouse Co. Ltd., Hamilton.

What can be more vital to our profession or our way of life than the engineers who will join our ranks a few years hence? What knowledge and skills will they require? How should they be trained? What will be expected of them in their work? The panel will examine and discuss these related problems whose successful solution demands the attention and efforts of all of us.

2.40 - 5.00 p.m. — **TECHNICAL PROGRAM**

6.00 p.m. SHERATON ROOM — **RECEPTION AND COCKTAILS, AS GUESTS OF HAMILTON INDUSTRY**

7.00 p.m. CRYSTAL BALLROOM — **CONFERENCE BANQUET**

8.30 p.m. CRYSTAL BALLROOM — **EVENING GUEST SPEAKER**

Why Buy "Made in Canada"

STUART ARMOUR Economic Adviser, The Steel Company of Canada Ltd., Hamilton, Ont.

Mr. Armour is one of Canada's foremost economists. His subject affects each one of us as an individual and also as a member of our community. The economic problems facing our country are complex but their solution depends on the actions of individual people.

9.30 p.m. CRYSTAL BALLROOM — **CONFERENCE BALL. DANCING TO CHRIS LOVETT AND HIS ORCHESTRA**
Dress informal. Corsages for the ladies.
Refreshments available.

All E.I.C. and A.P.E.O. members and their

REGIONAL CONFERENCE

Institute of Canada

Hotel, Hamilton

March 14, 1959

THE SPECIAL LADIES' PROGRAM

permits your lady to accompany you and ensures that her day will be just as enjoyable as yours. The Hamilton Branch E.I.C. Auxiliary and the Wives of Professional Engineers will be hostesses during the special afternoon program.

Arrangements have been made by these ladies to provide dressing accommodation in their homes for the visiting ladies who will not be staying overnight in Hamilton. The Brittany Suite will also be available to the ladies throughout the Conference.

TECHNICAL PROGRAM

2.40 p.m. Future Trends in Extractive Metallurgy

DR. L. M. PIDGEON, B.A., B.SC., PH.D., P.ENG.,

Professor and Head of Department of Metallurgical Engineering, University of Toronto

Dr. Pidgeon is a recognized authority on extraction methods of light metals and initially developed the dolomite-magnesium extraction process which has been adopted universally. Dr. Pidgeon's talk will be on new trends and techniques and will deal particularly with energy requirements in the metallurgical extraction field.

3.30 p.m. Outstanding Problems in Microwave Engineering

DR. G. B. WALKER, B.SC., PH.D.,

Electrical Engineering Staff, Assumption University, Windsor.

Dr. Walker is a recent arrival from the U.K., where he acquired extensive experience in the field of microwave transmission. This new field of engineering will be of interest to all engineers particularly now that we depend so much on this medium of communication in our own country.

4.10 p.m. Recent Developments and Research in Fan Design

J. BARRY GRAHAM, B.SC.,

Research Director, Buffalo Forge Co., and Canadian Blower and Forge Company.

Prior to his association with his present companies, Mr. Graham was on the staff of U.C.L.A. at the Los Alamos Atomic Laboratory. Every engineer can produce air. Mr. Graham also knows how to move it and by the very latest methods.

2.40 p.m. Corrosion in the Chemical and Petroleum Industries

STAN V. ANTENBRING, B.SC., M.E.I.C.,

Chief Construction Engineer, Imperial Oil Ltd., Sarnia, Ont.

The cost of corrosion to Canadian industry runs to many millions of dollars annually. Mr. Antenbring will discuss causes, effects and remedies for this most serious drain of maintenance dollars that faces us all no matter what our field of engineering.

3.30 p.m. Current Problems in Municipal Engineering

W. A. WHETEN, B.SC., M.E.I.C., P.ENG.,

Dep. City Engineer, City of Hamilton

Mr. Wheten will explain how demands of a rapidly growing city are successfully met with particular reference to sewage disposal, water distribution and pollution, road construction and maintenance. Mr. Wheten has had considerable experience in this type of work in different parts of the world.

4.10 p.m. Power and Canada

R. A. H. HAYES, B.SC., M.E.I.C., P.ENG.,

Vice-President, Sales, H. G. Acres & Co. Ltd., Niagara Falls.

Progress in Canada has closely parallelled our development and utilization of power and will continue to do so. Mr. Hayes has personally had a hand in the design and construction of many of our largest power developments. It would be difficult to obtain a speaker more qualified to present a paper on this interesting subject.

For the Ladies!!

11.00 a.m.	Brittany Suite	Registration and coffee hour
1.00 p.m.	Sheraton Room	Buffet Luncheon
2.30 p.m.	Sheraton Room	Fashions for '59

The entire Ladies' Program will this year be held in the Sheraton-Connaught Hotel. See above for some of the special arrangements that have been made to ensure that the ladies have a pleasant and enjoyable day.

ladies are cordially invited. Plan NOW to attend.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

Dr. Charles Camsell, M.E.I.C., former deputy minister of mines, and a past-president of the Engineering Institute, died on December 22, 1958, at the age of 82.

Born at Fort Liard, N.W.T., in 1876, he was the son of Captain Julian S. Camsell, Canadian Rifles, a chief factor in the Hudson's Bay Company. He received his early education at St. John's College, Winnipeg, and his B.A. degree at the University of Manitoba in 1894. Later he took post-graduate work in geology at Queen's University, and at Harvard and Massachusetts Institute of Technology.

Dr. Camsell spent the early years in exploration and study of the northwest.

These early adventures were published in 1954 by Ryerson Press in the book "Son of the North", an autobiography.

From 1894 to 1900 he travelled in Mackenzie River basin and in the region west to the Pacific Coast, taking part in geological survey work at Great Slave Lake, Great Bear Lake and the Coppermine River basin. During part of 1901 he was exploring the Moose River basin on James Bay for the Algoma Central Railways; in 1902 he traversed the woods buffalo country between the Peace River and Great Slave Lake, and acted as geologist to the Canadian Northern Railway Company in western Ontario and northern Manitoba in 1903. In the following year he joined the permanent staff of the Geological Survey, travelling from Dawson to the mouth of the Mackenzie River and exploring the Stewart and Peel Rivers. The year 1906 saw his activities

Ottawa Journal Photo
Dr. Charles Camsell, M.E.I.C.

transferred to British Columbia, where he worked for five years on economic problems. In 1914, in charge of exploratory work for the Geological Survey, he traversed the country between the Athabaska River and Great Slave Lake. From 1918 to 1920 he was in charge of the Vancouver office of the Geological Survey of Canada. In 1920 he was appointed Deputy Minister of the Federal Department of Mines, later the Department of Mines and Resources. He also became Commissioner of the Northwest Territories. He retired in 1946 as deputy minister, but held the post of Commissioner of N.W.T. for some time.

Dr. Camsell served on the E.I.C. Council in 1929 and 1930, and was president in 1932. He was president of the Canadian Institute of Mining and Metallurgy in 1947, president of the Royal Society of Canada in 1931, president and one of the founders of the Canadian Geographical Society. He held membership and offices in a number of other scientific and learned organizations.

Among his academic honours may be noted the degrees LL.D. which he received from Queen's University in 1922 and from the University of Alberta in 1929. The Royal Geographical Society awarded him the Murchison Grant in 1922 and the Founders Medal in 1945. The Institution of Mining and Metallurgy, London, presented him with its gold medal. The R. B. Bennett Empire Prize for 1945 was awarded to him for a paper presented to the Royal Society of Arts. The Professional Institute of the Civil Service awarded its medal to Dr. Camsell in 1946.

Gordon S. Stairs, M.E.I.C., chief engineer of the Nova Scotia Department of Highways and director of its new research and planning branch died suddenly in Toronto on October 5, 1958. He had been in Ontario on a study of the highway research program.

Born at Selma, Nova Scotia on August 31, 1889, he received his engineering education at Dalhousie University and at the Nova Scotia Technical College. He graduated with a B.Sc. degree in civil engineering in 1911.

During the early years of his career, he was employed on various engineering projects, by the Western Canada Power Company, Stave Falls, B.C. and by A. V. White, consulting engineer in Toronto.

Gordon S. Stairs, M.E.I.C.

In 1917 he was commissioned as a lieutenant in the Royal Canadian Engineers. After World War I he returned to Nova Scotia to be assistant engineer with the Halifax Works Department. Later he was town manager and engineer in Wolfville and in Windsor, N.S. Between 1928 and 1934 he served L. E. Shaw Limited and the Dominion Bridge Company Limited. He became resident engineer with the Department of Highways in 1934.

During World War II he served the Royal Canadian Air Force for five years in the Maritimes and Central Canada. In 1945 he returned to the Highways Department as division engineer of construction. He was appointed chief engineer two years ago.

Henrik Mugaas, M.E.I.C., civil engineer died at his home in Meaford, Ont., on August 4, 1958.

Mr. Mugaas was born on April 28, 1894 in the town of Evanger, Norway. He attended schools in Bergen, and technical high school at Darmstadt, Germany. After more technical training at Bergen, Mr. Mugaas began his career there. Coming to Canada toward the end of the 1920's, he worked on surveys for transmission lines.

From 1935 to 1943 he was with the Lamaque Gold Mines Ltd., Val D'Or, Que., as chief surveyor of the company. In 1943 he joined the R.C.A.F., and upon his release in 1946, he returned to the Lamaque Mining Co. at Bourlamaque, Que.

In 1951 he moved from Val D'Or, Que. to Meaford, Ont. where he worked on the general hospital, new public utilities, and also public and high schools.

In 1952 he accepted a position with the Department of National Defence on army construction. He also served the Central Mortgage and Housing Corporation for several years in the Maritimes.

John R. White, M.E.I.C., project supervisor, chemicals division of the Products Department of Canadian Industries Limited, Cornwall, Ontario, died in August 1958.

Born in Saskatchewan in the town of Parkside on September 2, 1916, he graduated from the University of Saskatchewan with a B.E. degree in mechanical engineering in 1938.

For two years he held various posts with the Saskatchewan Power Commission and the P.F.R.A. Moving East at the end of 1939, he worked with the Consolidated Paper Corporation, Three Rivers, Que. From 1940 to 1947 he was employed in the engineering departments of Defence Industries Limited and Canadian Industries Limited, as draughtsman, quantity surveyor, and assistant project engineer. In 1948 he was named estimating engineer of the Department of Development for the chemical division of Canadian Industries Limited, Montreal. In 1955 he was transferred to the Cornwall plant of the company.

• OBITUARIES

James Emmett Flynn, M.E.I.C., project engineer with Narod, Dawson & Hall, died recently in Vancouver.

He was born in Victoria, B.C., on January 4, 1914, studied forestry engineering at the University of British Columbia, graduating with a B.A.Sc. in 1942.

Upon graduation he joined the H. R. MacMillan Export Company as instrumentman on logging operations, becoming in 1945 survey chief on extensive topographic surveys on logging operations. In 1947 he joined Bloedel Stewart & Welch Ltd., as resident engineer for the construction and development of pulpwood resources in connection with establishing a new pulpmill. From 1949 to 1951 he was associated with Columbia Cellulose Co. Ltd., on the construction of a pulpmill at Prince Rupert, B.C.

Later he worked for the Central Mortgage & Housing Corporation and Defence Construction (1951) Ltd.

He joined Narod, Dawson & Hall, contractors for the construction of the Deas Island Tunnel, in 1957 as a project engineer.

Wing Commander D. G. Joy, M.E.I.C., former district director of air services, civil aviation at Winnipeg, died at York Mills, Toronto on October 30. He had been active in military and civil aviation from 1915 until his retirement from the Department of Transport in 1951.

Douglas Grahame Joy was born at Barrie, Ont., on February 16, 1887. He studied mechanical engineering at the University of Toronto, School of Practical Science, 1906 to 1910.

In the early part of his career he was associated with the Ontario Hydro-Electric Power Commission.

In World War I he served overseas with the Royal Flying Corps, winning the Air Force Cross. He had been one of the first graduates of the Curtiss Wright Aviation School in Toronto in 1916. He retired from the R.C.A.F. with the rank of Wing Commander in 1922.

In 1920 he returned to the Power Commission, but went into engineering contracting in 1922.

He joined the Department of Transport, Government of Canada, civil aviation branch, in Toronto in 1930. He was inspector of civil aviation in that area until after World War II.

Posted to Winnipeg then, he was district controller of air services concerned with the civil aviation, radio, meteorological and airways engineering divisions.

George Agar, M.E.I.C., retired vice-president and assistant to the president, Canadian Vickers Limited, Montreal, died on June 22, 1958.

He was born at Barrow-in-Furness, England on August 8, 1893, and attended technical school and mechanical engineering courses there

He was first associated with Vickers Ltd. in Barrow-in-Furness, as an apprentice. In 1913 he became a marine engine draughtsman. In 1917 he came to Canada and was appointed assistant chief marine engineering draughtsman and designer for Canadian Vickers Limited, Montreal.

By 1949 he had attained the post of executive engineer and assistant general manager of the company. Later, promotions were those of vice-president and executive engineer, and vice-president and assistant to the president. He retired in 1957.

Thomas O. Whillans, M.E.I.C., who retired in 1956 from the Government of Canada Patent Office, died on October 16, 1958.

He was born at Hurdman's Bridge, Ontario on November 22, 1890. He graduated from Queen's University with a B.Sc. degree in mechanical engineering in 1917.

Following graduation, he joined the Imperial Ministry of Munitions at Welland, Ont. From 1919-1920 he was a mechanical engineer with Pedlar People Ltd., Oshawa. In 1921 he joined the Canadian Patent Office as assistant patent examiner. In 1951 he was appointed assistant commissioner of patents with the Patent and Copyright Office of the Secretary of State Department. He was among those awarded a Coronation Medal in 1953 by Her Majesty Queen Elizabeth.

Harold Frederick Bush, M.E.I.C., general engineering supervisor at the Bell Telephone Company of Canada, Montreal, died on December 4, 1958.

Born in Ottawa on October 2, 1899, he attended primary and secondary schools there. In 1918, his university education was interrupted by World War I, in which he served in the Canadian Army Service Corps. Returning to McGill University upon his discharge from the army, he obtained a B.Sc. degree in electrical engineering in 1922.

Following his graduation he was for some time employed as engineer with the Hydro-Electric Commission of Ontario, at Ottawa. In November 1922 he joined the general engineering department of the Bell Telephone Company as an engineer. During the following twenty-three years he worked in the engineering department.

In 1946 he was appointed staff engineer in the headquarters staff engineering group where he played an important role in the decision to introduce microwave radio relay systems in Canada.

Mr. Bush was a member of the American Institute of Electrical Engineers, of the Canadian Standards Association and the Canadian Radio Technical Planning Board.

Calendar

Canadian Institute of Mining and Metallurgy, annual general meeting, Montreal, Que., April 13-15, 1959.

Operations Research Society of America, seventh annual meeting, Washington, D.C., Spring, 1959.

Institute of Environmental Engineers, third annual meeting, Chicago, Ill., April, 1959.

Symposium on the Chemistry of Cellulose, Tashkent, U.S.S.R., April, 1959.

Metal Powder Association, national meeting, Detroit, Mich., April, 1959.

American Institute of Electrical Engineers, early 1959 conferences; American power conference, (with ASME) Mar. 31-Apr. 2; railroad conference (with ASME), Chicago, April 7-9; electric heating conf., Philadelphia, Pa., April 14-15; electrical problems in the cement industry conference, Allentown, Pa., April 16-17; recording and controlling instruments conference, Philadelphia, Pa., Apr. 20-21.

American Society of Lubrication Engineers; national meeting, Buffalo, N.Y., April 21-23.

International Association of Geodesy; international symposium on instruments, Washington, D.C., Spring, 1959.

Aero Medical Association, Los Angeles, April 27-29, 1959.

International Association for Hydraulic Research; eighth congress, Montreal, during week of August 24, 1959. Information about participation is available from Leo Roy, c/o Quebec Hydro-Electric Commission, 107 Craig St. W., Montreal 1, Que.

Fifth World Petroleum Congress; The Coliseum, New York, May 30 to June 5, 1959. Congress Secretariat, 527 Madison Ave., New York 22, N.Y.

National Industrial Production Show; (also a display by British Manufacturers organized by the British Board of Trade, and the Birmingham Exchange and Engineering Centre), Toronto, May 4-8, 1959.

Chemical Institute of Canada; conferences of the protective coatings subject division, Toronto, Feb. 19, Montreal, Feb. 20, 1959.

American Society for Quality Control, Toronto Section; sixth annual forum, Hart House, University of Toronto, March 7, 1959.

American Meteorological Society; national meeting, Chicago, Ill., Mar. 24-27, 1959.

American Society for Metals, Montreal Chapter; 1959 educational lecture series, January to March. H. Neville Mason, P.O. Box 371, Station H., Montreal, Que.

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations.

BRITISH COLUMBIA

Consulting Engineers Division

Some suggestions for stimulating B.C. payrolls through the increased use of B.C. products were presented to the Provincial Cabinet by the Association of Professional Engineers of British Columbia.

In a Brief prepared by the Consulting Engineers Division of the Association, it was pointed out that direct benefit would accrue to B.C. manufacturers, contractors and suppliers if engineering projects involving the use of public money employed permanent residents of the province as the prime consulting engineers. Among the advantages cited are the familiarity of B.C. professional engineers with local conditions, building codes, and business practices. Because of this local knowledge they design for and specify locally available products and services, to the general economic advantage of the province.

The brief was presented on behalf of the Association by President R. E. Wilkins, P.Eng., Past President George C. Lipsey, P.Eng., D. H. Drake, P.Eng., and Registrar J. A. Merchant, P.Eng.

ONTARIO

Annual Meeting of A.P.E.O.

Andrew W. F. McQueen, P.ENG., M.E.I.C., of Niagara Falls, Ont., is the 1959 president of the Association of Professional Engineers of Ontario. He took office during the annual meeting on January 24. He succeeds C. T. Carson, P.Eng., as head of the organization.

In business life, Mr. McQueen is president of H. G. Acres & Co. Ltd., consulting engineers. At present the firm is undertaking two large hydro-electric projects in West Pakistan. A member of the A.P.E.O. since 1938, he has served on the Executive Council during the last two years, and last year was the Association's first vice president.

He is a graduate (1923) in civil engineering from the University of Toronto, and received the professional degree C.E. from his alma mater in 1932.

Elected first vice-president for 1959 is Dwight S. Simmons, general manager of manufacturing, Imperial Oil Ltd., Toronto. The second vice president is John W. Holmes, design engineer, Canadian General Electric Co. Ltd., Peterborough.

The following councillors were also elected, two for each of the five engineering branches, in addition to one appointed for each branch by the Lieutenant-Governor-in-Council.

Civil branch: Tullis N. Carter, vice president and general manager, Carter Construction Co., Toronto, and William A. Clarke, chief engineer, Ontario Dept. of Highways, Toronto. The appointed representative is V. S. Murray, also of Toronto.

Chemical and Metallurgical branch: Thomas H. Adair, assistant director of engineering and metallurgy, Ontario Research Foundation, Toronto, and Edmund P. Lewis, senior chemical engineer, Polymer Corp. Ltd., Sarnia. One councillor to be appointed.

Electrical branch: Robert L. Hicks, engineer, distribution planning and design dept., Toronto Hydro-electric System, and Gordon M. McHenry, consumer service engineer, Ontario Hydro-electric Power Commission, London. The appointed representative is Dr. J. Herbert Smith, Toronto, president of Canadian General Electric Co. Ltd.

Mechanical, Aeronautical and Industrial branch: Donald L. Angus, a partner in the consulting engineering firm of H. H. Angus & Associates Ltd., Toronto, and Lawrence C. Sentance, manager of the Defence Apparatus Division, Canadian Westinghouse Co. Ltd., Hamilton. The appointed representative is Dr. G. Ross Lord, head of the mechanical engineering department, University of Toronto.

Mining branch: William E. Bawden, chief engineer of mines, Ontario Dept. of Mines, Toronto, and Dr. Marc Boyer, Deputy Minister, Canadian Dept. of Mines and Technical Surveys, Ottawa. The appointed representative is Dr. George B. Langford, head of the department of geological sciences, University of Toronto.

The new Executive Council convened at the Association's annual meeting which held Saturday, January 24, at the Royal York Hotel, Toronto.

Science Teacher Honoured

The newly established award to Ontario's "maths and science teacher of the year" has been won by H. E. Totten who is head of the mathematics department at Toronto's Forest Hill Collegiate.

Mr. Totten was selected over 17 other teachers nominated across Ontario by the various districts of the Ontario Secondary School Teachers Federation. Presentation was made at the annual meeting.

T. R. Loudon Receives Award

A pioneer in Canadian aviation, Prof. Thomas R. Loudon, P.Eng., of Toronto, received the Association's highest honour, the Professional Engineers' Gold Medal.

The citation reads: "The Professional Engineers' Medal is presented by the Association of Professional Engineers of Ontario to Thomas Richardson Loudon, B.Sc., C.E., P.Eng., Professor Emeritus of civil and aeronautical engineering, University of Toronto, who as professor of civil and aeronautical engineering, has made a valuable contribution to the professional and educational life of his country".

Students Receive Awards

Recipient of student awards of the Association were: A. M. Hale, a graduate of University of Toronto, who is employed by Preston Woodworking Machinery Co., and H. R. Whiteley of Ottawa, a graduate of Queen's, who is in England on an Athlone Fellowship.

Gordon Churchill, Guest Speaker

Trade and Commerce Minister Gordon Churchill paid tribute to the work being done by Canada's engineers both at home and abroad. He addressed the annual meeting.

"Canadian engineering firms", he said, "are already capitalizing on Canada's reputation overseas. Against the toughest competition, contracts are being secured in overseas countries in such diversified fields as frequency conversion of electrical plant, pulp and paper consulting engineering, bridge design and mining development".

Canadian firms competed recently, he said, for major contracts to provide defence telecommunications systems for NATO countries in Europe, radio broadcasting equipment for Latin American countries, and airborne navigation systems for use in the United States, Europe and Japan.

Personals

News of the Personal Activities of Members of the Institute

Rt. Hon. C. D. Howe, P.C., Hon. M.E.I.C. (B.Sc., Massachusetts Institute of Technology 1907) has been elected to the board of directors of RCA Victor Company Limited.

D. C. Turner, M.E.I.C. (B.A., chem., McGill 1932) staff assistant, Canada Starch Company, Cardinal, Ont., has been elected chairman of the Brockville Branch of the Engineering Institute.

J. W. G. Scott, M.E.I.C. (B.Sc., civil, New Brunswick 1949) partner in the firm Turnbull & Scott, Saint John, N.B., is the choice of the Saint John Branch of the Institute as chairman for the current year.

E. Bodmer, M.E.I.C. (mech., Switzerland 1944) is the new chairman for the Baie Comeau Branch of the Institute. He is associated with the Quebec North Shore Paper Company.

R. E. Wilkins, M.E.I.C. (B.Sc., civil, Queen's 1936) has been appointed assistant to the president of B.C. Engineering Co. Ltd., Vancouver. He was formerly superintendent of civil engineering design for the company. He is president of the Association of Professional Engineers of B.C. and the Military Engineers' Association of Canada.

James W. Kerr, M.E.I.C. (B.A.Sc., elec., Toronto 1937) has been appointed president and chief executive officer of Trans-Canada Pipe Lines Limited. He is the former vice-president and general manager of the Canadian Westinghouse Company's apparatus products group, at Hamilton.

H. T. Miard, M.E.I.C. (B.A.Sc., civil, British Columbia 1933) has been appointed deputy minister, Department of Highways, of British Columbia. He has been with the Department since 1947, most recently as assistant deputy minister.

D. C. Turner

J. W. G. Scott

E. Bodmer

Rear Admiral/(E) B. R. Spencer, M.E.I.C. (Royal Naval Engineering College, England, 1929) has been promoted from engineer in chief to chief of naval technical services at National Defence Headquarters, Ottawa.

W. A. Friebel, M.E.I.C. (B.Sc., elec., Manitoba 1933) has been named manager of utilities of the City of Saskatoon. He is the former city engineer.

C. A. Stollery, M.E.I.C. (B.Sc., civil, Alberta 1941) has been elected to the board of directors of Royalite Oil Company, Limited. He is vice-president of Poole Construction Company Limited.

A. W. Purdy, M.E.I.C. (B.Sc., civil, Queen's 1949) has accepted a position as district sales manager for the Canada Cement Company Ltd. at Calgary, Alta. He was formerly district sales manager for the Maritime Cement Company Ltd., at Moncton, N.B.

D. C. Macpherson, M.E.I.C. (B.S., Queen's 1924) is vice-president of the firm C. E. Macpherson Limited, Kingston.

E. J. Cole, M.E.I.C. (B.Sc., civil, Saskatchewan 1944; B.A., physics, Sask., 1946) has been promoted from assistant city engineer to city engineer of the City of Saskatoon.

A. J. McIntyre, M.E.I.C. (B.Sc., elec., Manitoba, 1947) has joined the St. Lawrence Corporation Limited, Three Rivers, Que., as assistant plant engineer. He was formerly assistant project engineer with Hanright and Company at St. Catharines, Ont.

M. E. J. O'Loughlin, M.E.I.C. (B.A.Sc., chem., Toronto 1947) of Imperial Oil Limited has been transferred to the Halifax refinery as plant superintendent.

Allan G. Moffat, M.E.I.C. (B.A.Sc., Toronto 1944) was appointed manager of Haddin, Davis and Brown (Manitoba) Limited, late in 1958.

A picture of Mr. Moffat was included

J. W. Kerr

H. T. Miard

A. W. Purdy

A. G. Moffat

B. R. Spencer


A. M. Thomson


M. d'Amours


H. M. Sherwood

in the November 1958 issue page 96, with an incorrect caption. The picture is repeated in this issue.

Rev. J. E. Page, S.J., M.E.I.C. (B.Sc., civil, Manitoba 1945; M.Sc., community planning, Manitoba 1958) former staff member of St. Paul's College at Winnipeg, is now a theology student at the Jesuit Seminary in Toronto.

E. R. Graydon, M.E.I.C. (B.A.Sc., civil, Toronto 1935) of the Dominion Bridge Company Limited, was recently named manager of the Ontario division. He was formerly chief engineer of that division.

A. M. Thomson, M.E.I.C. (B.Sc., civil, Saskatchewan, 1948) has been appointed technical sales representative for construction chemicals in Alberta and British Columbia for Dewey & Almy Chemical Division, W. R. Grace & Co. of Canada Limited, Montreal.

T. M. Claughton, M.E.I.C. (H.N.C., elec., Oldham, England 1943) until recently with the Montreal Engineering Company Limited, will be for approximately one year with C. A. Energia Electrica de Venezuela, Maracaibo, Venezuela.

M. d'Amours, M.E.I.C. (B.A.Sc., elec., Laval 1945), former superintendent of operations, Quebec Power Company, has been named general superintendent.

Gordon Barnholden, M.E.I.C. (B.Sc., chem., Saskatchewan, 1948) former plant manager, Canada Creosoting Company Ltd., Calgary, has been appointed superintendent of the company's British Columbia operations.

G. W. Redwood, M.E.I.C. (B.A.Sc., mechanical sciences, Cambridge 1946) succeeds R. I. Stevens as works engineer of the Shawinigan plant of Canadian Industries Limited.

E. W. Blackmore, M.E.I.C. (B.Sc., McMaster Univ., 1940), formerly products superintendent at the Toronto tar plant of the Dominion Tar and Chemical Company is presently assistant works manager at the Hamilton tar plant.

P. A. Brett, M.E.I.C. (B.Sc. elec., Manitoba, 1948), is district manager at the Winnipeg office of English Electric Canada, and John Inglis General Engineering Division.

R. M. Ferguson, M.E.I.C. (B.Sc., civil, Alberta 1946) is assistant chief engineer for Canadian Brown Steel Tank Company, Brandon, Manitoba.

H. M. Sherwood, M.E.I.C. (B.Sc., chem., Alberta 1933) has been promoted to sales manager, textile fibres division of Canadian Industries Limited, Montreal.

W. G. Muir, M.E.I.C. (B.Sc., mining, Nova Scotia Technical College 1931) is mine manager for Dominion Rock Salt Company Ltd. at Goderich, Ont.

J. M. Ferguson, M.E.I.C. (B.Sc., civil, Saskatchewan 1946) has been transferred to the head office of Mannix Co. Ltd. in Calgary, Alta.

Walter J. Francl, M.E.I.C. (Dipl. Engr., mechanical and agriculture, Vienna 1948) has been appointed chief design engineer of the municipal engineering department for the Edmonton office of Stanley, Gimble Roblin Ltd.

T. J. Boyle, M.E.I.C. (B.Sc., civil, Saskatchewan 1937) is assistant engineer of bridges, Canadian Pacific Railway Company. He has been a special engineer on matters connected with the St. Lawrence seaway affecting the C.P.R.

Kaljo Tammik, M.E.I.C., (B Sc., civil, Gothenburg, Sweden) has recently been appointed design engineer with M. M. Dillion & Co. Ltd., London, Ont.

P. J. G. Carrothers, M.E.I.C. (B.A.Sc., chemical and textiles, British Columbia 1944; S.M., M.I.T. 1952) an associate scientist for the Fisheries Research Board of Canada, at Vancouver has been transferred to the biological station at Nanaimo, B.C.

Dale A. Bailey, M.E.I.C., (B.E. civil, Sask., 1953; M.S.C.E.. Purdue 1958) has taken over a post with the Federal Department of Public Works, Regina, Sask. In his new work he is resident engineer, highways division.

A. L. Gourley, M.E.I.C., (B.Sc., mech., Queen's, 1946), is teaching at the Perth & District Collegiate Institute, Perth, Ont. Mr. Gourley was formerly with Phillips Electrical Company, in Brockville, Ont.

G. Y. Sebastyan, M.E.I.C. (B.Sc.E., civil, Michigan, 1953; M.Sc.E., Michigan, 1958), has joined the construction branch of the Air Services, Department of Transport, Ottawa.

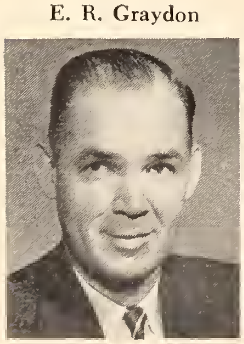
Major W. E. Blake, M.E.I.C. (B.Sc., civil, Queen's 1947) is a military observer for U.N. in India and Pakistan. He was formerly at the First Canadian Infantry Division headquarters.

Louis Mathys, M.E.I.C. (M.Sc., mech., Federal Institute of Technology, Zurich, 1942), is in Cuba as chief engineer for the acid and metal recovery plant of Krebs S.A. Paris.

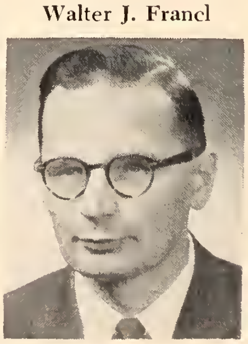
W. D. Alexander, JR.E.I.C., (B.Sc., M.E., mech., Manitoba 1950) has recently been released from the Royal Canadian Horse Artillery. He is assistant professor in the mechanical engineering department at the University of Manitoba.

N. W. E. Lee, JR.E.I.C., (M.Sc., civil, Purdue, 1954), of Hunting Technical and Exploration Services, has been transferred to Montreal. He is the company's project engineer and general representative in Photographic Survey Corporation (Quebec) Ltd.

E. R. Graydon

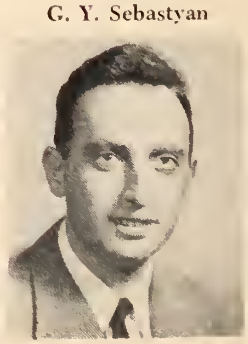


Walter J. Francl



K. Tammik

G. Y. Sebastyan



N. W. E. Lee

• PERSONALS

G. Montambeault, JR.E.I.C. (B.Sc.Eng., mining, Laval 1952) has been transferred to the Copper Cliff works of Canadian Industries Limited, as project engineer.

Pierre Lefrancois, JR.E.I.C. (B.A.Sc., che., Ecole Polytechnique 1956) is doing post-graduate studies in industrial administration at the Carnegie Institute of Technology, Pittsburgh, Pa.

G. A. Metcalfe, JR.E.I.C. (B.A.Sc., civil, Toronto 1951) a maintenance engineer with the Department of Highways of Ontario has been transferred from the Chatham district to the Ottawa district.

Armand Couture, JR.E.I.C. (B.A.Sc., 1953, civil, M.S., Laval) is a transportation engineer in the Montreal office of the Foundation of Canada Engineering Corporation Ltd.

F/L A. V. Rugienius, JR.E.I.C. (B.Eng., chem., McGill 1951) former project officer for the directorate of aircraft engineering at R.C.A.F. headquarters, Ottawa, is studying at the College of Aeronautics, England.

J. Edward Henderson, JR.E.I.C. (B.Sc., civil, Queen's 1955) has completed research work under an Athlone Fellowship. He has a position as assistant to the turbine erector, Warsak hydro electric project in West Pakistan.

Lee Morrison, JR.E.I.C. (B.E., geological, Saskatchewan 1957) has been appointed exploration geologist for Benguest Consolidated, Inc. at Baguio City in the Philippines.

J. Shumiatcher, JR.E.I.C. (B.Eng., mech., McGill 1950) formerly field manager for Canadol Construction Ltd., Calgary, has become general manager of the firm.

J. M. Bentham, JR.E.I.C. (B.Eng., civil, McGill 1947), has been appointed engineer of track, Canadian Pacific Railway Company.

R. F. J. Falconer, JR.E.I.C., (B.A.Sc., civil, Toronto, 1955), is a project engineer with James F. MacLaren Associates, consulting engineers in Saint John, N.B.

Raymond Hebert, JR.E.I.C., (B.A.Sc., civil, Ecole Polytechnique, 1953), has been town engineer and assistant manager for the Town of Seven Islands, Que., since August, 1958.

W. D. Goodings, JR.E.I.C., (B.Sc. civil, Queen's 1951) is with Proctor & Redfern, consulting engineers of Toronto as resident engineer at Brantford, O.W.R.C.

R. C. Hermann, JR.E.I.C., (B.A.Sc., civil, U.B.C., 1952), has been appointed supervisor of construction cost in the accounting section of the general engineering department of the Aluminum Company of Canada Limited, Montreal.

George V. Cox, JR.E.I.C., (B.Eng., civil, McGill, 1956), is with the O'Brien Engineering Company Ltd. in Nassau, Bahamas.

L. J. Eibner, JR.E.I.C., (B.Sc., civil, Manitoba, 1948), until recently western division engineer for Laminated Structures Limited, Vancouver, has been transferred to the Montreal branch of the firm as sales co-ordinator.

Jan Dlouhy, JR.E.I.C., (B.Eng., chem., McGill, 1954; Ph.D., McGill, 1957), has joined the technical department of Cyanamid of Canada Ltd., Niagara Falls, Ont. as a senior engineer.

R. P. Malis, JR.E.I.C., (B.Sc., civil, Manitoba, 1954), until recently resident engineer at the Kootenay National Park for the Department of Northern Affairs and National Resources, has been transferred to Ottawa, Ont. as an administration engineer.

W. J. Monkman, JR.E.I.C., (B.Sc., elec., Alberta, 1949), is a design engineer with the Electrical Group of the Boeing Aeroplane Company, Renton, Washington.

Thomas V. Stephens, S.E.I.C. (B.Sc., elec., New Brunswick 1957) has been transferred to Esquimalt, B.C. as a lieutenant on the staff of the manager of electrical engineering of H.M.C. Dockyard.

Douglas W. Ferrier, S.E.I.C. (B.Sc., civil, Alberta 1957) has joined Associated Engineering Services Ltd., Edmonton, Alta.

Jean-Claude Hebert, S.E.I.C. (B.Sc., mech., Ecole Polytechnique 1958) is with the Canadian Broadcasting Corporation as assistant Quebec regional engineer.

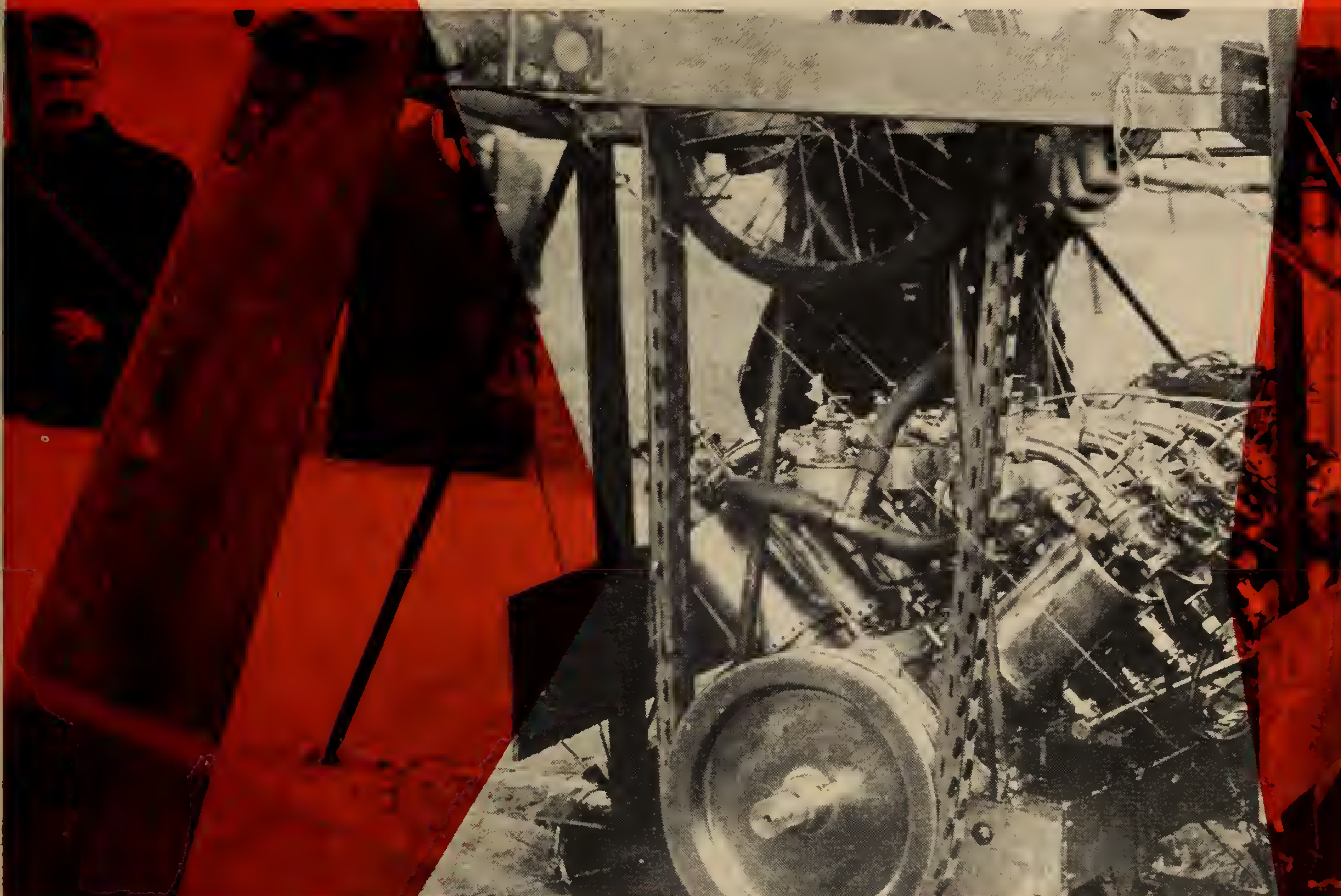
Paul E. Tremblay, S.E.I.C. (B.A.Sc., mechanical and electrical, Ecole Polytechnique 1958) is doing post-graduate studies in London, England under an Athlone Fellowship.

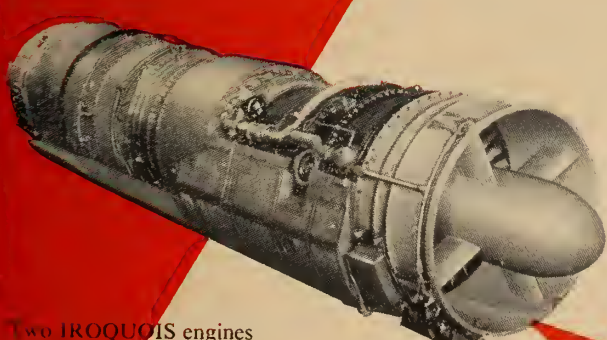
David G. Hobart, S.E.I.C. (B.Eng., mech., McGill, 1958), is studying economics at Pembroke College Cambridge, England.

F. T. White, S.E.I.C., (B.A.Sc., eng. and bus., Toronto, 1957), has joined International Business Machines, Toronto as system analyst.

Harold Norrish, S.E.I.C. (B.A.Sc., civil, British Columbia, 1958) is an assistant project engineer with the Greater Vancouver Sewerage and Drainage District.

Jean F. Riel, S.E.I.C. (B.A.Sc., mech., Ecole Polytechnique 1958) is at the State University of Iowa, for one year of study in hydraulics.





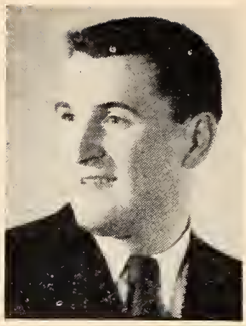
• PERSONALS

Paul P. Steinhubl, S.E.I.C., (B.E., civil, Saskatchewan 1958) has been appointed assistant district engineer with the Saskatchewan Municipal Road Assistance Authority.

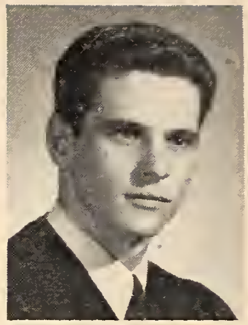
Jean Paul Voisine, S.E.I.C., (B.S.A., elec., Laval 1958), is working as an electrical engineer for Canadair Ltd. in Montreal.

P. J. Blanchard, S.E.I.C., (B.Sc., C.E., New Brunswick, 1958), is attending the University of Michigan.

D. G. Turner, S.E.I.C., (B.Sc., elec., Manitoba, 1958), is employed as scientific officer with the Defence Research Board, Canadian Armament Research and Development Establishment, Valcartier, Que.



J. C. Hebert



P. Tremblay

B. de Cardaillac

W. S. Wilkinson, S.E.I.C., (B.E., chem., Nova Scotia Technical College, 1958), is working for the Shell Oil Company of Canada.

R. B. Swansburg, S.E.I.C., (mech., Acadia, 1953; B.E., mech., N.S.T.C., 1955), has joined Kenwood Mills Ltd. as a sales and service engineer in Arnprior, Ont.

J. H. Bertin Tremblay, JR.E.I.C., (B.A.Sc., chem., Laval 1958), is employed in the Quebec Department of Health.

Gilles N. Theberge, S.E.I.C., (B.Eng., civil, McGill 1958), is assistant engineer for Canadian Pacific Railway at Farnham, Que.

Flying Officer D. R. Bundy, S.E.I.C., (B.E. mech., Saskatchewan, 1958), is a radar officer at R.C.A.F. station in Lac St. Denis, Que.

Wm. D. McGilvray, S.E.I.C., (B.Sc., mech., Saskatchewan, 1958), is with the Steel Company of Canada Ltd., Hamilton, Ont.

Bertrand de Cardaillac, S.E.I.C., (B.Eng., elec. (comm.), McGill, 1957) is with the chief electrical engineer of Asbestos Corporation Ltd.

Paul R. Bennett, S.E.I.C., (M.Sc., mech., Queen's, 1958), is employed as instrument engineer with the Spruce Falls Power & Paper Co. Ltd., in Kapuskasing, Ont.

Vincent G. Beckie, S.E.I.C., (B.Sc. Geological, Sask. 1958) is working with the groundwater section of the water rights division, Department of Agriculture, Province of Saskatchewan.

Seaforth M. Lyle, S.E.I.C., (B.Eng., elec., McGill 1958), is doing post graduate work at McGill University in the field of analogue computers.

J. Martino, S.E.I.C., (B.Sc., mech., Man., 1958), is employed as a reactor-mechanical engineer with the maintenance and power branch, Engineering Services Division, Atomic Energy of Canada, Deep River, Ont.

Claude Maillet, S.E.I.C., (B.Eng., communication, McGill, 1958), is now serving as a lieutenant in the RCEME Corps, Canadian Army (R).

R. Kenneth Cox, S.E.I.C., (B.Eng., civil, McGill, 1958), has become assistant engineer for W. D. Laflamme Ltd., contractors, Hull, Que.

INSTRUMENTATION

(Continued from page 77)

onment. If anything could be done to reduce this by better selection of alloys or other materials for instrument components it would be a step in the right direction, the survey concluded.

Trend Toward Automation in Stock Preparation

The stock preparation department in a paper mill furnishes stock to the paper machines, proportioned as to fibres and chemicals necessary to develop the varied sheet characteristics needed. The method of preparation may be manual, semi-automatic or automatic.

Comparative air-dry tons of stock furnished per man-hour since the beginning of automation, including colouring, broke-pulping, purchased pulp slushing and handling from storage, average as follows: *manual* 0.538 furnished per man-hour; semi-automatic, 1.53 tons furnished per man-hour; and fully automatic, 1.83 tons furnished per man-hour. This comparison shows there has thus been a decided increase in output per man-hour as the stock preparation moved toward automation.

Reasons for this continuous progress include a) increased labour costs; b) the need for improved uniformity free from human error, and c) the high cost of buildings, storage and equipment, particularly in mills where space is at a premium. Complete automation of stock preparation is a next step in the manufacture of a quality product at a minimum cost.

Advantages of Electrical Equipment

Although, currently, in most mills up to 90 per cent of the control systems are pneumatic, electronic devices enter into modern production systems and processes in many phases. Where put into service through carefully designed circuits and selected components, they provide a valuable and rugged controlling medium. Reluctance, in the past, to use such equipment arose from fears that delicate components and mysterious circuits would call for constant vigilance by skilled mechanics.

Electronic control devices are dependable in their performance under the most rigid standards. "The Building Block" method of circuit assembly, using sealed-in components, brings a new strength and reliability to industrial electronic applications.

Due to the fact that standard electronic control panels with the same basic assemblies can be used in so many places in one paper mill, spare parts inventories can be kept low.

There is one disadvantage in too wide a use of electronic devices, however, which may become a boomerang. When the equipment becomes too old and breakdowns call for service and replacements, there may be a lack of specialists to do the repair work on old and obsolete types of equipment, now superceded by more efficient and up-to-date models.

Modernization Needed

In the United States a special survey was recently completed of business needs for modernization in industry. The cost to replace obsolete facilities for all manufacturing was assessed at $34.8 billion. Of the total, needs for modernization in the pulp and paper industry was set at $2.655 billion.

Since roughly one-third of the United States' wood-fibre requirements comes from Canada, expenditure for modernization in Canadian pulp and paper mills might require an outlay of some $1.32 billion, assuming a similar age of manufacturing capacity as that of the pulp and paper plants in the United States.

The U.S. survey referred to determined that of the pulp and paper manufacturing capacity in the U.S., 49 per cent had been installed prior to Dec. 31, 1945; 17 per cent had been installed between that date and Dec. 1950; while the remaining 34 per cent of capacity had been installed between December 1950 and December 1957.

While no similar survey has been published for Canada, based on government figures for production of wood pulp at the end of each of these periods a rough comparison can be arrived at. Such a comparison would indicate that some 55 per cent of Canadian manufacturing capacity in the pulp and paper industry had been installed prior to 1945; another 20 per cent between then and late 1950, with the remaining 25 per cent installed between Dec. 1950 and December 1957.

In other words, a somewhat larger proportion of Canadian pulp and paper machinery and equipment than that of the industry in the United States may be presently in need of modernization, though what proportion of this modernization would be for instrumentation can only be surmised.

KAPLAN TURBINES

(Continued from page 61)

ent but usually to an unobjectionable degree, and in this case were aggravated by an unusually flexible oil head support and very sensitive blade response.

Another point of interest is the method by which pressure is maintained on the oil in the runner hub. The hub is connected through a central pipe in the main shaft to a small reservoir at the top of the oil head. Relative elevations of the oil head and hub ensure that static oil pressure within the hub always exceeds the water pressure of the tailwater under all conditions including shutdown. Proper sealing of the hub would make this feature unnecessary, but it was felt that it provided an extra insurance in case leakage of any type should develop.

We believe that Beechwood was the first application of an electrohydraulic governor in Canada. Our Company is neutral on this subject and installed this type of governor at the request of the consultants. It is felt that any advantages are more in the dispatching field than in mechanical governing. Its application will undoubtedly be followed with great interest.

Aside from the oil head problems mentioned, the units had no more than the usual run-in problems. The turbine performed smoothly over full gate range. Governing of the gates and blades was smooth and responsive.

In a paper given before the joint E.I.C.-ASME meeting in 1956* it was stated that 20% of the installed hydro capacity in the United States is of Kaplan design. The comparable figure in Canada at that time was less than 1%. Though conditions in Canada and the United States vary considerably in many basic respects, it is reasonable to assume that the number of Kaplan installations will sharply increase as undeveloped power sites become fewer in number and many sites have to be reconsidered. The Beechwood Development may be considered as an important step in this trend.

Acknowledgement

The authors wish to acknowledge the assistance obtained from staff members.

*G. Dugan Johnson, The Kaplan Turbine in Canada, The Engineering Journal, 1956, June, p. 769.

NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute

and abstracts of the papers presented at their meetings

AMHERST

G. R. Pond, JR.E.I.C., *Sec.-Treas.*

TIDAL POWER STUDIES undertaken for the Annapolis River dam were discussed by J. D. Conlon at a branch meeting on December 12, 1958. Mr. Conlon is chief engineer, Maritime Marshlands Rehabilitation Association.

General interest prompted a brief but rigorous investigation of the tidal power potential as well as the plant which could utilize the rock fill causeway, the main river control sluices and the temporary flow bypass structures which the Annapolis River dam, presently under construction for marshland protection and a highway bridge replacement will comprise.

BAIE COMEAU

G. W. Scott, M.E.I.C., *Correspondent*

DR. J. L. LUSSIER, of Quebec North Shore Paper Company spoke at the meeting of October 31, 1958.

Dr. Lussier discussed operation studies carried out in the woods department of the Quebec North Shore Paper Co. The greater part of his discourse covered the statistical analysis of evidence accumulated as the result of woods operations' studies. These analyses determine the most economic policy to be followed in a given set of operational circumstances. The talk was supplemented with statistical equations and diagrams.

THE ANNUAL GENERAL MEETING was held on November 20.

In his report the retiring chairman, V. M. Wallingford, said that following the inaugural banquet held in December 1957 which was attended by the Institute's president and general secretary the branch had had a most successful year.

The following executive was unanimously elected at the general meeting: Chairman, E. Bodmer; secretary, L. A. G. Tellier; treasurer, T. G. Rust; executive members, G. W. Scott, P. Suttie, J. M. Pope; representative for Labrieville, G. Laboissiere.

A dance which was attended by 60 members and guests followed the business of the meeting.

BELLEVILLE

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

J. R. MILLS, vice-president, Foundation Company of Canada, spoke at the branch meeting of December 8.

His talk on the Dew Line was followed by an excellent coloured film.

For the construction of this defence project advance parties, supplies, equipment and prefabricated buildings were landed by plane to establish campsites. Fuel, heavy equipment and structures were transported by ship during the short Arctic summer.

CENTRAL BRITISH COLUMBIA

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

THE ANNUAL MEETING was held in Vernon, December 5, 1958.

An interesting prelude to the meeting was a dedication ceremony held at the "lookout" over Kalamalka Lake, seven miles south of Vernon. A monument was erected to commemorate the work of pioneer engineers, amongst whom is A. E. Ashcroft who was responsible for the design and construction of the Vernon irrigation district.

Similar plaques and cairns were erected at Oliver, Penticton, Kelowna and Revelstoke as a project of the Central B.C. Branch in connection with British Columbia's Centennial. Dedication ceremonies will be carried out at these centres. The engineers honoured by these plaques are:

Oliver: F. H. Latimer, in charge of South Okanagan Land Irrigation Project, 1905-1940; *Penticton:* A. H. McCulloch, engineer in charge of construction of Kettle Valley Railway which reached Penticton in 1914; *Kelowna:* F. W. Groves, in charge of development of water storage and irrigation 1908 till 1948; *Revelstoke:* Major A. B. Rogers, C.E., who was in charge of construction of C.P.R. through the Selkirk Mountains, 1880-1885.

CAPE BRETON

H. M. Aspinall, M.E.I.C., *Correspondent*

A SOCIAL EVENING and dance was held by the Branch on November 17 with about 40 couples attending. It was a very successful evening socially.

CHALK RIVER

C. A. Crawford, M.E.I.C., *Chairman*

THE CHALK RIVER PROJECT was discussed by three A.E.C.L. speakers on November 19. They were: Dr. D. A. Keys, scientific advisor to the president; Dr. G. C. Butler, head, Biology Division; and Dr. J. M. Robson, head, Nuclear Physics Division.

The members and ladies found the information most interesting. Dr. Keys' talk was a history of the project.

Dr. Butler explained the two uses of biology in atomic engineering: the use of pile products, and the determining of the effect of radiation on life. According to J. M. Robson, the physicist now has more dependence on the engineer, as new devices are developed.

Bishop A. H. Sovereign (right) retired bishop of the Anglican Church in the Yukon and N.W.T., officiated at the dedication of a plaque at Kalamalka Lake. At left is E. R. Gayfer, branch chairman.

• BRANCH NEWS

EDMONTON

I. G. Finlay, M.E.I.C., *Correspondent*

THE SOUTH SASKATCHEWAN RIVER DAM was discussed at a meeting of the Edmonton Branch on November 26. The speaker was R. Peterson, soil mechanics engineer, P.F.R.A.

Mr. Peterson discussed the history of the project, described the reservoir, irrigation, power and water supply scheme. His familiarity with the plan from soil observations to cost and status of construction made this a most informative session for the record audience of this year, 117.

KITCHENER

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

PRESIDENT K. F. TUPPER visited the branch on November 24, speaking to the members about his observations during a recent visit to Russia.

KINGSTON

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

NEW DEVELOPMENTS in explosives and blasting techniques were described on November 25 by John Bell of Canadian Industries Limited, Montreal.

Mr. Bell discussed the use of millisecond detonating relays, the use of nitrocarbonitrates as blasting agents, and the recent introduction of ammonium nitrate and fuel oil mixtures. A film, "Blasting a New Niagara" illustrated the blasting techniques required during the construction of Sir Adam Beck No. 2 development.

LONDON

G. W. Chorley, M.E.I.C., *Correspondent*

THE ANNUAL VISIT OF THE PRESIDENT to London was on November 26. President K. F. Tupper was the luncheon guest of E. Rippingille, Jr., president of G. M. Diesel Ltd., together with Dr. E. V. Buchanan and the executive of the Branch.

Mrs. Tupper was entertained at lunch by the executive of the Engineers Wives Association. In the evening a cocktail party was given in their honour, and a dinner meeting was held.

In the afternoon Dr. Tupper addressed the engineering students at the University of Western Ontario.

NIAGARA PENINSULA

D. A. Barnum, M.E.I.C., *Chairman*

A JOINT E.I.C.-A.P.E.O. MEETING was held in Niagara Falls, on October 16, chaired by the E.I.C. branch. C. Bruce Hill, president of E.T.F. Tools Limited, spoke on Educational and Technical Advances in Russia.

JOHN FISHER was the speaker at a joint A.P.E.O.-E.I.C. meeting held at St. Catharines, Ont., on November 18. This meeting was chaired by the A.P.E.O. branch. Mr. Fisher's subject was Building a Greater Canada.

PRESIDENT K. F. TUPPER and Mrs. Tupper, with General Secretary Garnet T. Page and Mrs. Page, were guests of the Branch on November 27. The executive met for discussions with the visitors, and for dinner at the Niagara Falls Club.

THE BURLINGTON SKYWAY was the subject of a talk on December 4 by H. W. H. Casperd. This was also a joint meeting, chaired by the E.I.C. branch. A full description of the planning, building of the Skyway was given by Mr. Casperd, supervisor of field engineering and J. T. Gregg, supervising bridge engineer.

NORTHERN NEW BRUNSWICK

Stewart K. Henry, JR.E.I.C.,
Branch Correspondent

A GENERAL MEETING of the Northern New Brunswick Branch was held on November 18, with 20 engineers present.

P. J. Delicaet was elected vice-chairman, by acclamation. It was announced that R. C. Eddy would represent the Branch on the E.I.C. Nominating Committee, and that A. W. Rowe and R. W. Rankine were appointed branch auditors. Membership of the branch nominating committee was also announced. The branch annual meeting was planned for May 29, 1959.

John A. McLaren, E.I.C. field secretary was a guest at this meeting. A delicious lunch was served by compliments of the Connolly Construction Limited.

MONCTON

V. C. Blackett, M.E.I.C., *Sec.-Treas.*

THE ENGINEERS WIVES ASSOCIATION of the Moncton Branch held a pot luck supper meeting, on November 13, arrangements for which had been made by Mrs. H. L. Purdy, social convenor.

The president, Mrs. Wesley M. Steeves, chaired the meeting. The guest speaker, Dan Billing, co-ordinator of civil defence for southern New Brunswick was introduced by Mrs. Anne Nason, and gave a brief outline of the work being carried on by Civil Defence.

Mrs. H. L. Purdy, Mrs. Anne Nason, Mrs. V. C. Blackett, and Mrs. Wesley M. Steeves, executive of the Engineers' Wives Association, Moncton Branch.

The secretary-treasurer's report was read, and Mrs. J. W. Ward was named to the executive. Mrs. M. F. K. Leighton who had attended the 72nd annual meeting of the Institute in Quebec City, spoke of work being done in other wives' branches across Canada. Mrs. G. J. Gaudet, Mrs. R. C. Gillespie and Mrs. C. O. Lockhart, transferred back to Moncton, and Mrs. R. F. MacKenzie and Mrs. J. A. Baxter were welcomed as members.

A CHRISTMAS DANCE AND BUFFET SUPPER held on December 5 at the Brunswick Hotel, was enjoyed by members and their wives. It was sponsored by the Wives Association.

Buffet table decorations were supplied by Mrs. D. A. Foster. Each lady received a corsage. Prize winners during the evening were Mr. and Mrs. R. C. Gillespie, Mr. and Mrs. H. J. Crudge and Mr. Jack Veness.

Music was provided by the Maurice Stevens orchestra.

J. A. MCLAREN, eastern field secretary of the E.I.C., visited Moncton on November 13, and was the guest at dinner of the branch executive. Later, there was a conference at which Mr. McLaren explained and emphasized certain Institute services available to the membership. He referred particularly to the library at Headquarters. There was a lengthy discussion regarding *The Engineering Journal*. The executive were unanimous that the most desirable articles were those dealing with major Canadian engineering works, either under construction or recently completed.

NIPISSING, UPPER OTTAWA

D. W. Briden, JR.E.I.C., *Sec.-Treas.*

LADIES NIGHT, November 7, 1958, was the occasion of the visit to the branch of President and Mrs. K. F. Tupper and General Secretary Garnet T. Page.

The event took the form of a dinner and dance held at the Golden Dragon restaurant, North Bay, Ont. Dr. Tupper spoke to the eighty-four members, wives and guests present about his recent trip to Russia. It was a most enjoyable and interesting evening.

• BRANCH NEWS

OTTAWA

Arthur H. Graves, JR.E.I.C.,
Publicity Chairman

ALAN HAY, M.E.I.C., general manager F.D.C., and Walter B. Bowker, information division, F.D.C., spoke on "The National Capital Plan" on October 9, 1958. Approximately 60 persons attended.
J. W. KERR, M.E.I.C., vice-president and general manager, apparatus products, Canadian Westinghouse Co. Ltd. addressed the joint meeting (with A.I.E.E.) on October 16, on "Some Impressions of the U.S.S.R." Attendance exceeded 100 persons.
REGULAR LUNCHEON, November, 1958, was addressed by C. K. Hurst, M.E.I.C. on "Interesting Sidelights of Ripple Rock". Attendance, 75 persons.
LT. COL. J. I. THOMPSON, C.O. Army Survey Establishment spoke at November 20 meeting on "Topographical Mapping in Canada". Attendance was 50.

SARNIA

LEROY D. SMITHERS, president and general manager of Dow Chemical Co. of Canada, spoke to the Sarnia Branch of

Clair Huston, Leroy D. Smithers, Chairman R. A. McGeachy.

the Institute on November 20.
Mr. Smithers was the final speaker in the Branch's eight-week professional Development course.

SUDBURY

F. Jackson, M.E.I.C., *Correspondent*

PRESIDENT K. F. TUPPER, visiting the branch on November 10 with General Secretary Garnet T. Page, attended a dinner dance.
Dr. Tupper, introduced by W. J. Ripley, M.E.I.C., talked about Engineering in the U.S.S.R., and made other observations of his recent trip.

UNIVERSITY OF MANITOBA

Brian K. Laxdal, S.E.I.C.
Student Chairman

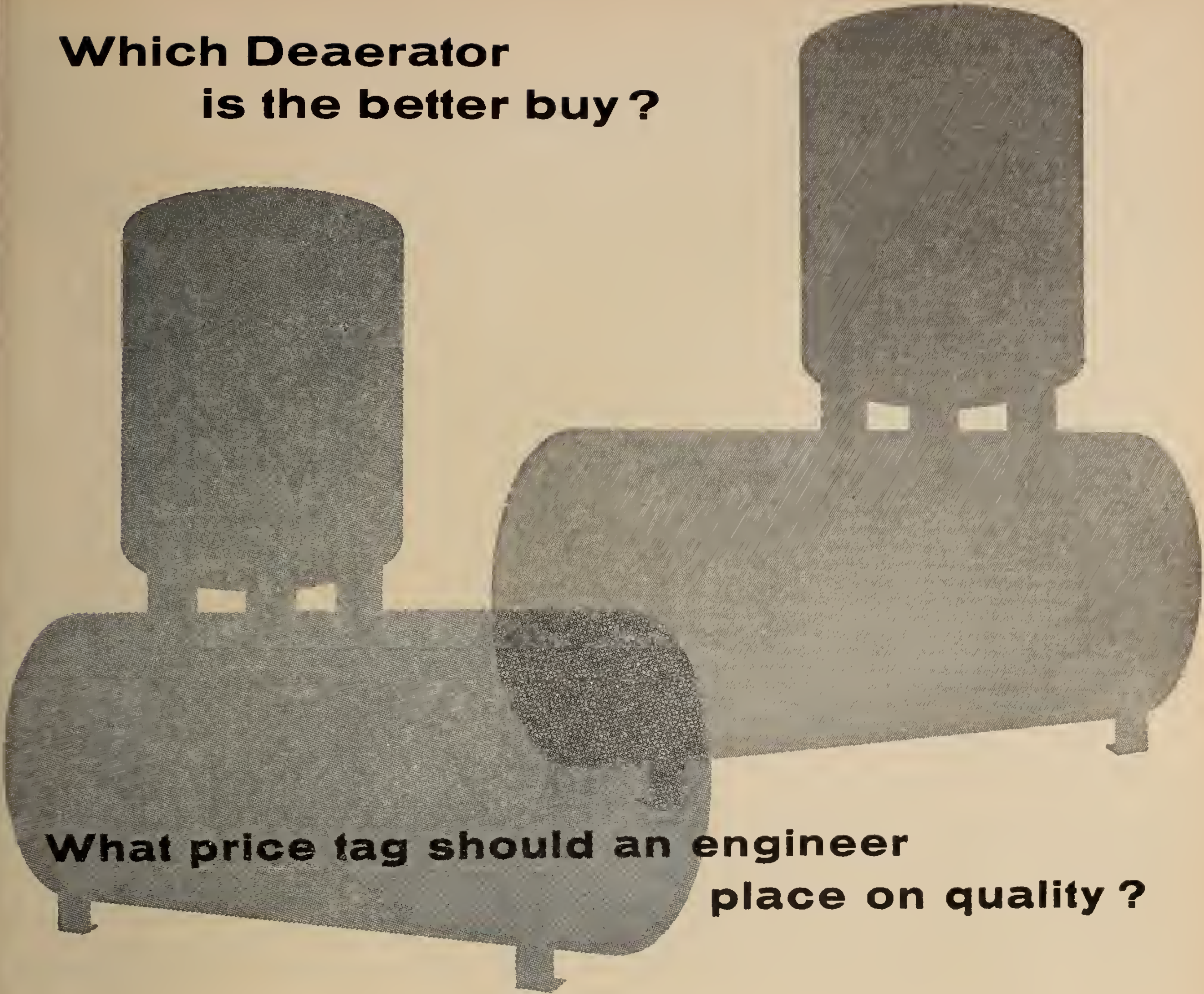
EACH THURSDAY at 12:30 to 1:30 p.m., in the Engineering Building, films and speakers as follows, have been presented to the University of Manitoba, Student Section.
Oct. 2–Operation Bluejay, (Attendance 200); Oct. 9–Dawn's Early Light (200); Oct. 23–Strange Case of Cosmic Rays, (200); Oct. 30–Skywatch on "55", (200).
Nov. 6–Speakers: H. F. Brehaut, Manitoba Bridge and Engineering Works; M. J. Davies, chief geologist, Manitoba Department of Mines and Natural Resources.
Nov. 13–Investment panel–sponsored by Winnipeg Chamber of Commerce; panel members: E. Jackson, moderator; L. Cemeron, mutual investments; J. MacKnight, stocks and bonds; S. Scott, life insurance.
Nov. 20–Dr. K. F. Tupper, president E.I.C.; Nov. 27–film, Phoenix Tower, (200).
Membership drive, Nov. 4-8; approximately 80 new memberships resulted.

WINNIPEG

P. M. Abel, JR.E.I.C., *Correspondent*

THE RIPPLE ROCK explosion was discussed at a meeting, November 20, by the technical service manager, explosives department, Dupont Company of Canada, R. S. Harding.
The meeting (attended by 70) first saw the excellent colour film prepared by Dupont which deals with the project. Afterwards, the meeting was conducted on a question and answer basis.
PRESIDENT K. F. TUPPER and Mrs. Tupper, with General Secretary Garnet T. Page were guests of the branch on November 19, 20,. 1958.

Which Deaerator is the better buy?



What price tag should an engineer place on quality?

These two medium sized deaerators look alike. We designed both. They have the same outlet capacity, carry similar guarantees and meet the ASME code. But one costs $2000 more than the other.

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News of Other Societies

C.C.A. Meets at Montreal

The 41st annual meeting of the Canadian Construction Association was held at the Queen Elizabeth Hotel in Montreal, January 18-21, 1959. Over a thousand delegates were welcomed by the Hon. Sarto Fournier, mayor of Montreal. J. Eric Harrington, M.E.I.C., vice-president, Anglin Norcross Quebec Limited, was elected president of the Association for the coming year.

Association President, Harold J. Ball of Kitchener, noted that the volume of construction had continued to rise in 1958, while many other industries had experienced a decline in activity. As Canada's largest industry construction had thus played a key role in our country's overall economic stability. "The upward trend should continue in 1959 to a total of perhaps $7½ billion," he predicted. "Because of improved techniques the construction dollar will give relatively more value than ever before, increased costs notwithstanding. The industry still has almost unlimited scope for further advances."

Noting increased wintertime construction and virtual elimination of shortages as outstanding achievements in the past year, he voiced the impression Canada had now reached a stage where there was a definite *surplus* of contractors. In spite of record volumes there would be a "buyer's market" with bitterly keen competition being a standard condition.

Committee Reports

Apprenticeship Committee chairman, H. C. Nicholls, reported a 4 per cent increase in registration of indentured apprentices during 1958 or to 8,593, in eight provinces having apprenticeship agreements with the Federal Government. This growth however was at a diminishing rate compared with the 9 per cent increase in 1956 and the 7 per cent increase in 1957.

Chairman D. H. Jupp of the Business and Contractor Relations committee reported progress in the development of bid depositories had been limited, although establishment of such arrangements in Ottawa last September for plumbing and electrical trades was highly significant.

Chairman Robert Hewitt of the Construction Equipment Committee reported the publication of a revised edition early in 1958, of the CCA "Rental Rates on Contractors Equipment" schedule.

Chairman V. L. Leigh of the Housing Committee drew attention to the record breaking total of more than 150,000 completions in 1958. Cost and availability of land were more of a problem than actual construction costs. Land prices for NHA units had risen roughly 5½ times as much as building costs during the 'fifties'.

Chairman G. F. Lipsett of the Labor Relations Committee reported submission of a Brief to the Minister of Labour.

Chairman A. Blake Robertson of the Legislation committee reported on follow-up activities arising out of the brief submitted to the Minister of National Revenue in December 1957 relative to Department policies on reporting income. Although the department had not adopted the Association's first submission a number of related matters were clarified and agreed upon.

Chairman W. A. Marshall of the Sales Tax Committee drew attention to the fact that federal sales tax exemptions on material and equipment available to junior governments tended to discourage them to set up their own forces to carry out work normally going out to competitive tender. He urged the present discrimination against contractors be removed. A major sales tax hardship existed, he pointed out, in the different tax treatment given to competing materials.

Chairman Ray Brunet of the National Joint Wintertime Construction Committee, stated that although volume and employment this winter should be greater this winter than in 1957-58, upwards of one third of those unemployed were construction workers. He expressed hope all those having authority over the initiation of construction work would also plan *now* and in ensuing months so projects would be scheduled to provide employment *next* winter wherever possible.

On the second day's morning session delegates heard addresses by Major-General H. A. Young, Deputy Minister of Public Works, and President R. G. Johnson of Defence Construction (1951) Ltd. General Young's remarks are reported in another section.

Defence Construction

R. G. Johnson, president of Defence Construction (1951) Limited told delegates that in 1958 DCL had awarded contracts to the value of $90 million, compared with 58 million in 1957, while it entered 1959 with work outstanding valued at some $69 million. DCL expects expenditures on defence contracts in 1959 may be nearly doubled those of 1958, or nearly $100 million.

A total of $86 million was the present estimated Canadian contribution towards engineering and construction on Colombo Plan projects with which DCL is associated. Up until the end of 1958 Canadian expenditures on these projects amounted to $54 million.

NUCLEAR CONGRESS 1959

Forty sessions will be held during the five-day Nuclear Congress, 1959, which begins April 5 at the Public Auditorium in Cleveland, Ohio. The Engineering Institute is one of the twenty-nine sponsoring societies. The Congress will be comprised of the Fifth Nuclear Engineering and Science Conference, the Seventh Atomic Energy Management Conference, the Seventh Hot Laboratories and Equipment Conference, and the Atomfair.

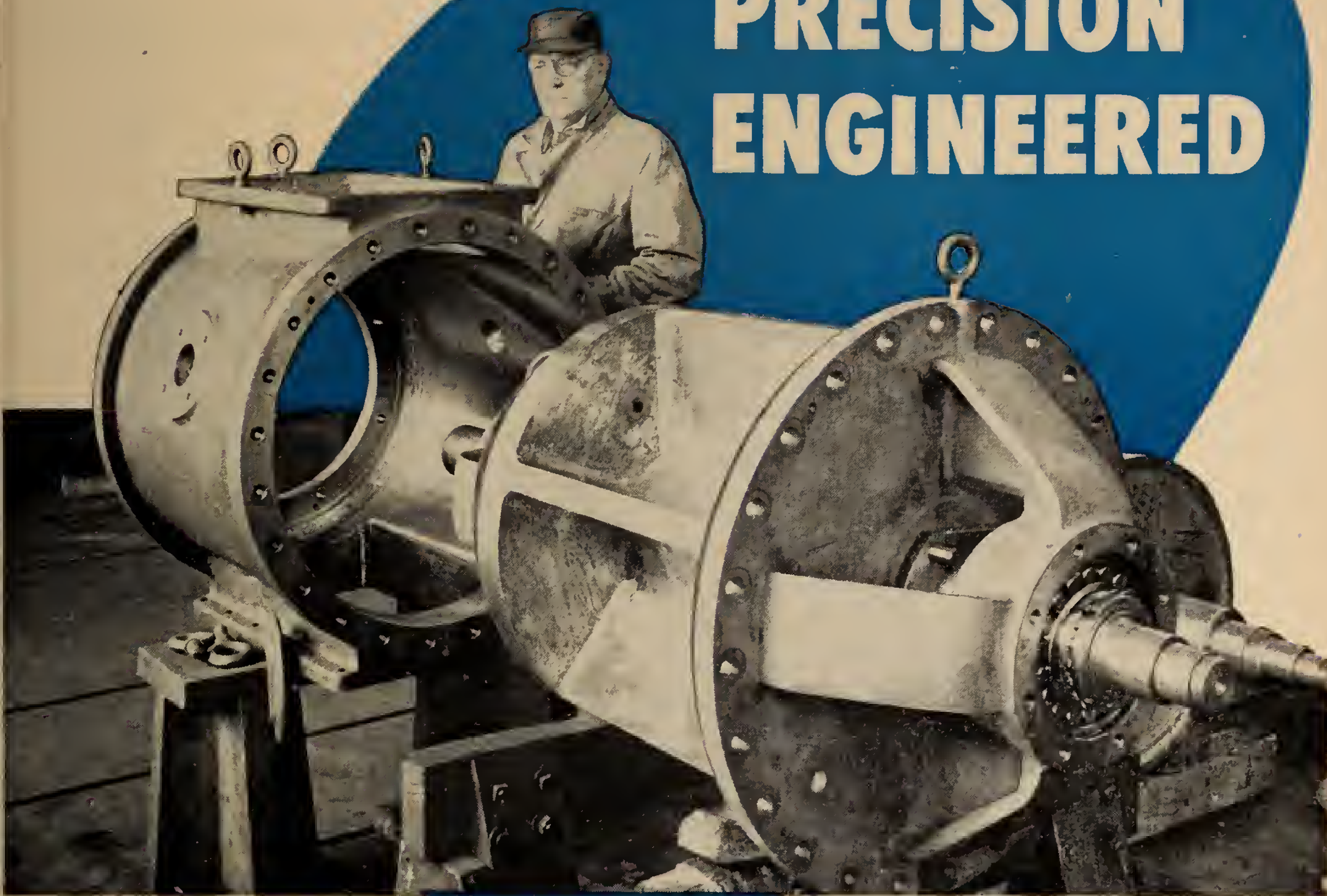
Nuclear Engineering and Science Conference

There are 24 sessions scheduled in the Nuclear Engineering and Science Conference. Their subjects are: Waste Disposal; Nuclear Research Test and Training Facilities; Simulation and Experimental Instrumentation; Water Supply; Nuclear Instruments; Nuclear Component Design; Health Physics; Heat Transfer; Reactor Instrumentation; Chemistry and Chemical Processing; Power Reactor Design; Instrumentation; Nuclear Fuel Processing Plants — Design and Practice; Radio Tracers in the Process Industries; Reactor Physics; Fuel Technology; Isotope Application; European Power Reactor (A), (B) and (C); Fusion Processes; Metallurgy and Materials 1, II; Reactor Operating Experience and Maintenance.

The Atomic Energy Management Conference consists of a series of discussions on the broad application of nuclear power and influence, and the potential of the nuclear field on the sociological and economic structure of industry.

The seventh conference on hot laboratories will deal with the highly technical details of the development of equipment and operation of laboratories for atomic energy.

The Atomfair, which is open for the whole five days duration of the Congress from 9:00 a.m. to 5:00 p.m. is an exhibit by major manufacturers of the latest products, components and services for the peaceful uses of atomic energy.



LIBRARY NOTES

ADDITIONS TO THE INSTITUTE LIBRARY • REVIEWS • BOOK NOTES • STANDARDS

BOOK 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.

CABMA REGISTER OF BRITISH INDUSTRIAL PRODUCTS FOR CANADA, 1958-59

There are over 3200 British products listed in the sixth edition of this most useful Register. More than 4000 British firms interested in export are listed, with information on their products, address and Canadian distribution arrangements. Canadian associated companies of British firms are listed separately. (Canadian Assoc. of British Manufacturers and Agencies. London, Iliffe, 1958. 653p.)

THREE STEPS TO VICTORY

This volume, sub-titled "A Personal Account by Radar's Greatest Pioneer" is the history of the development of Radar and its wartime use. Other inventions are also described: I.F.F (Identification, Friend or Foe); Oboe; Gee and Rebecca-Eureka. (Sir Robert Watson-Watt, M.E.I.C., London, Odhams, Toronto, Nelson, Foster and Scott, 1957. 480p., $6.50.)

*PRINCIPLES OF ELECTRONIC INSTRUMENTS

The first part of the book deals with instruments to measure electrical quantities by electronic methods. The second part deals with non-electrical measurements by electronic instruments, such as velocity, time, sound, light, pressure and temperature, and radioactivity. Emphasis is placed on the circuits of instruments rather than their use, and on circuits designed to operate at relatively low frequencies. (G. R. Partridge. Englewood Cliffs, N.J., Prentice-Hall, 1958. 393p., $11.00.)

THERMODYNAMICS OF ENGINEERING SCIENCE

The aim of this volume is to give undergraduate students a basic knowledge of thermodynamics and its applications.

The first eleven chapters can be considered as an introductory course.

The remaining chapters are on applied thermodynamics and cover compressors, turbomachinery, internal combustion engines, gas turbines, refrigeration and heat pump, jet propulsion, etc. (S. L. Soo. Englewood Cliffs, Prentice-Hall, 1958. 620p., $12.65.)

MATTER, EARTH, AND SKY

The latest book by this popular author, this volume covers the field of the physical sciences in non-technical language, with a wealth of diagrams and illustrations.

The first section discusses the field of "classical physics" illustrated by things familiar in everyday life such as the motion of a pendulum, waves, the flight of a tennis ball, etc. The second section deals with microcosms, the world of modern physics and chemistry, molecules, atoms and nuclear energy. The final section is concerned with things much larger than man, the interior of the earth; the oceans; the solar system; the stellar systems and the history of the universe. (G. Gamow. New York, Prentice-Hall, 1958. 593p., $10.00.)

*PRINCIPLES AND APPLICATIONS OF RANDOM NOISE THEORY

The author indicates how to formulate difficult noise problems, derive their solutions, and obtain proper physical design and interpretations. The book discusses probability theory, random noise analysis, random processes, engineering systems, correlation functions, power spectral, density functions, and optimum filters. (J. S. Bendat. New York, Wiley, 1958. 431p., $11.00.)

PULP AND PAPER MANUAL OF CANADA, 1958

This edition of the Manual contains a review of the industry in 1957, and also contains statistics of paper production. The papers in the second section deal with the use of hardwood and methods for keeping the moisture content of air low.

By far the largest part of the Manual is a trade directory, with a classified listing of machinery supply and service companies, trade names, and foreign companies represented in Canada. (Gardenvale, P.Q., National Business, 1958. 469p.)

*TECHNOLOGY OF COLUMBIUM (NOBIUM)

A summary of the present status of knowledge of columbium. The seventeen papers included study this metal from the standpoint of economic and supply aspects, properties, extractive and physical metallurgy, analytical problems, and various specialized aspects. The papers were presented at a symposium sponsored by the Electro-Chemical Society, May 1958. (Ed. by B. W. Gonser and E. M. Sherwood. New York, Wiley, 1958. 120p., $7.00.)

FLAVOR RESEARCH AND FOOD ACCEPTANCE

Based on four one-day conferences organized by Arthur D. Little, Inc., this volume can be called the authority on one of the basic factors of food product success, that is, flavour.

The chapters are all by experts in the field, and contain references for further reading. (New York, Reinhold, 1958. 391p., $10.00.)

*CASTILLA'S SPANISH AND ENGLISH TECHNICAL DICTIONARY. VOLUME 1: ENGLISH-SPANISH; VOLUME 2: SPANISH-ENGLISH

An extensive dictionary primarily concerned with the fields of engineering technology, although commercial and legal terms are included as are words of importance in everyday language because of the continual use they receive. Abbreviations and commercial terms are also included, while those used only in the pure sciences are in general excluded. (New York, Philosophical Library, 1958. 2v., $45.00.)

FUNDAMENTALS OF THERMODYNAMICS

The book presents an introduction to thermodynamics and its application in modern engineering problems. The first three chapters cover the basic laws of thermodynamics, following chapters cover: the pure substance (steam); vapour power cycles; vapour refrigeration cycles; the perfect-gas system; gas compression cycles; gas power cycles; gas and gas-vapor mixtures; steady flow of fluids; flow through pipes and ducts; heat transfer. A new two-colour Mollier chart is included. (C. M. Leonard. Englewood Cliffs, Prentice-Hall, 1958. 376p., $8.00.)

*CALCUL DE L'ECOULEMENT EN CONDUITES SOUS PRESSION OU A SURFACE LIBRE D'APRES LA FORMULE DE MANNING-STRICKLER

An extensive compilation of tables for the calculation of water flow in pressure conduits, and in channels with free surface, both open and covered. Under each of the main classes the tables are subdivided by cross-section — circular, ovoid, trapezoidal, etc., and figures are given for small dimensional changes over a wide range of size and shape. Graphical representation is a feature of some sections and numerical examples are given. (P. A. Arghyropoulos. Paris, Dunod, 1958. 326p., 3800 fr.)

• LIBRARY NOTES

*THE ENCYCLOPEDIA OF CHEMISTRY (SUPPLEMENT)

Intended to bring the original 1957 volume up to date, this supplement gives strong emphasis to the impact of nuclear phenomena on chemistry. Some of the topics given consideration are porphyrins, plasma, propellants, cermets, dosimetry, fluoridation, resonance, jet propulsion, liquid state, as well as many others. (Ed. by G. L. Clarke. New York, Reinhold, 1958. 330p., $10.00.)

*JET PROPULSION

The author attempts to explain concepts from the fundamental engineering laws rather than from an equation standpoint. Emphasis is given to the aerothermodynamics of gas systems, and topics discussed include the diffuser, nozzle, Fanno line, isothermal, normal shock, and oblique shock flow. The flow through each engine component and the components themselves are discussed, as are the combined performance characteristics of engines and air frames. (W. J. Hesse. Toronto, Pitman, 1958. 567p., $9.75.)

*TECHNICAL DRAWING, 4TH ED.

A thorough revision of a well known text. Areas which have been given particular attention in this edition include geometrical constructions; dimensioning and notes; threads, fasteners, and springs; shop processes; engineering graphics; structural drawing; topographic drawing; welding representation. The majority of the illustrations have been redrawn, and the format of the book has been enlarged to permit clearer illustrations. The entire volume has been revised to reflect the latest American Standards. (F. E. Giesecke and others. Galt, Brett-Macmillan, 1958. 844p., $7.50.)

*FLUID PRESSURE MECHANISMS, 2ND ED.

Studies the mechanism of hydraulic and pneumatic machinery, particularly from the viewpoint of their essential principles. Among the changes made in this edition are the inclusion of new material on slide valves, jacks with force limitation, special couplings, and synchronization systems. The chapter on servo systems has been substantially revised. (H. G. Conway. Toronto, Pitman, 1958. 235p., 32/6.)

*ENVIRONMENTAL SANITATION

Emphasis is placed on planning for the small community of less than 5000 persons. Among those aspects given consideration are control of communicable disease; location and planning in relation to sites for camp, industrial, housing, and similar uses; water supply sources, construction, treatment, and distribution; waste-water treatment and disposal; swimming pools and bathing beaches; food, insect, rodent, and noxious weed control; hygiene of housing. Empirical formulae and rules of thumb are applied when they are advantageous. (J. A. Salvato, Jr. New York, Wiley, 1958. 660p., $12.00.)

FEDERATION INTERNATIONALE DE LA PRECONTRAINTE: PROCEEDINGS OF THE SECOND CONGRESS

All the papers presented at the second congress of the Federation held in Amsterdam in 1955 are contained in this volume.

The five sessions considered: Function of grouting and anchorages in the behaviour of prestressed elements; Experience and problems concerning the manufacture and the use of steel for prestressing; Progress of precast prestressed work in the factory and the assembly by prestressing on the site of precast units; Moment distribution in statically indeterminate prestressed structures beyond the elastic phase; Influence of plasticity on the strength and instability of thin prestressed shells. (F. I. P. London, Cement and Concrete Assoc., 1958. 990p., £5.)

POWER TRANSFORMERS FOR HIGH-VOLTAGE TRANSMISSION

Written by the Chief Designer of the Transformer Department of Bruce Peebles and Company, this book shows some of the work being done at that company, and illustrates some of the factors to be taken into account in the design of transformers. (D. McDonald. Edinburgh, Bruce Peebles, 1958. 95p.)

DYNAMIC DECADE

The discovery of oil in Alberta has made a great difference to the economy of that province, and indeed to that of the whole country. This is the history of the search for oil in Alberta, the bringing into production of Leduc, Redwater, Pembina, etc. The author discusses methods of transporting and marketing oil, natural gas, pipe lines, production figures, etc. He considers the effect oil has had on Alberta's economy, the new industries it has attracted, and the problems which have been created. (E. J. Hanson. Toronto, McClelland and Stewart, 1958. 314p., $5.00.)

EXPERIMENTELLE UNTERSUCHUNGEN AN VERSCHIEDEN STARK KONVERGENTEN, SCHLANKEN ROTATIONSKORPERN BEI MAFIG HOHEN UBERSCHALLGESCHWINDIGKEITEN

This study starts with an explanation of the selection of bodies to be measured, the measuring of equipment used, the measurement of forces etc. Following this, the theory giving the main differential equation of the special flow; the release of the linear differential equations for supersonic speed; the calculation of pressure distribution etc. The results of measurements are given, taking into account tenacity. (H. R. Voellmy. Zurich, Leemann, 1958. 82p., 17 Sw. Fr. Mitteilungen aus dem Institut fur Aerodynamix No. 24.)

REFLEX KLYSTRONS

This survey of the current knowledge on reflex klystrons commences with a general introduction and the historical background. The topics covered include: cavity resonators and output systems; electron dynamics of the reflex klystron oscillator; load effects; engineering aspects; representative and unconventional reflex klystrons. The final chapter is devoted to future trends in the field. Many bibliographic references are included. (J. J. Hamilton. Toronto, Ryerson, 1958. 260p., $9.00.)

• LIBRARY NOTES

VEHICLE SPEEDS ON ONTARIO HIGHWAYS

An analysis of the speeds of 8499 motor vehicles on the highways of Ontario, based on information gathered at 16 sampling stations, on the open highway, on 2-, 3-, and 4-lane highways. Much of the material is presented in the form of graphs. (H. M. Edwards. Kingston, Queen's University, 1958. 65p., mimeog. Some reports available for distribution.)

°ENGINEERING MATERIALS

This volume is divided into three parts, the first of which deals with various kinds of aggregates, cements, concretes, bituminous materials, stone, timbers, glass and plastics. The second part deals with properties of metals and alloys including alloy steels, wrought iron, cast iron, malleable cast iron, and nonferrous metals and alloys. It concludes with the preservation and testing of materials. The authors are a group of engineering materials professors in American universities. (Committee on Engineering Materials. Toronto, Pitman, 1958. 616p., $8.50.)

°EFFECT OF SURFACE ON THE BEHAVIOR OF METALS

Four papers, the first of which deals with the preparation of surfaces for examination and with modern methods of examining the topography and structure of surfaces. This is followed by a paper that shows how the treatment that a surface has received affects its future chemical behaviour. A summary of the present state of knowledge on the relationship between surface condition, frictional resistance and wear is then given and followed by a paper on the influence of the surface on the physical properties of metal. These papers comprise the lectures given at the Institution of Metallurgists Refresher Course, 1957. (London, Iliffe for the Institution of Metallurgists, Toronto, British Book Service, 1958. 100p., $4.50.)

ENGINEERING DRAWING AND DRAWING OFFICE PRACTICE, 2ND ED.

Apart from a few minor corrections, the only change in this edition is the inclusion of an introductory chapter of recommendations and comments on British Standard 308, Engineering Drawing Practice, issued in 1953.

The book is intended for students, and starting from first principles covers all that is necessary for a good groundwork in engineering drawing. (P. S. Houghton. Toronto, British Book Service, 1958. 277p., $4.50.

NUCLEAR POWER YEAR BOOK 1958/59

The review articles in this second edition of the Year Book cover British nuclear power in 1958; nuclear instruments in 1958; progress in fuel element design; thermonuclear research at Harwell; uranium mining prospects. There are seven international and forty-one national atomic energy authorities listed. The technical data section has been expanded, in particular the reactor physics chapter has been enlarged, and material included on nuclear constructional and coolant metals. The isotope section has been enlarged, and the isotope tables contain data on 1391 nuclides.

This is a useful volume. (Ed. by W. Davidson. London, Rowse Muir, 1958. 570p., £3. 3. 0.)

BRITISH NARROW GAUGE RAILWAYS

A factual account of the few narrow-gauge railroads still operating in Britain and two which are not, including the only cog-wheel railway, that up Snowdon Mountain, and the only underground one, that in Glasgow. The gauges on the fifteen lines described range from one foot three inches to four feet. Details are given on construction, rolling stock and traffic. Illustrations, many of which are by the author, add to the interest of this fascinating book. (R. B. Jones. Toronto, Macmillan, 1958. 110p., $3.50.)

°HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL. VOLUME 1: CONTROL FUNDAMENTALS

This volume, the first in a series of three, provides information which forms a foundation for the later volumes. It covers mathematics as applied to control, such as sets and relations, Boolean algebra, probability, and statistics. This is followed by a compilation of the latest techniques of numerical analysis, as well as comparisons of the various techniques; material on information theory, smoothing, filtering, and data transmission; thorough treatments of feedback control theory and of operations research. Emphasis is placed on practical methods of applying the theory. (Ed. by E. M. Grabbe and others. New York, Wiley, 1958. Various paging, $17.00.)

THE UPPER ATMOSPHERE

An account of the phenomena of the upper atmosphere being studied during the International Geophysical Year, outlining present day knowledge of the subject. The techniques used in investigation are described, including sound and radio waves, balloons and rockets. Methods of finding the speed of rockets and their positions, and of interpreting their signals are discussed. (H. S. H. Massey and R. L. Boyd. London, Hutchinson, 1958. 333p., 63/-.)

°THE SCIENCE OF HIGH EXPLOSIVES

Stresses the physical chemistry of detonating explosives. The fundamental principles and information necessary for technical applications is given, including commercial blasting, demolition, shaped charges, fast particles, shock and blast wave propagation, impact loading, strength, penetration, and conditions for explosion of materials. Procedures for computing thermo-hydrodynamic properties and products of detonation are also presented. (M. A. Cook. New York, Reinhold, 1958. 440p., $22.50.)

• LIBRARY NOTES

°AUTOMATIC MEASUREMENT OF QUALITY IN PROCESS PLANTS

Papers covering two aspects of the field: those that survey the experience gained with the control instruments now in use, and those that explore the potential plant application of analytical techniques currently used only in the laboratory. Specific topics include techniques for gas stream analysis, spectrometric methods, liquid stream analysis, new techniques for fluid stream analysis, and measurement of various physical properties. (Society of Instrument Technology. Toronto, Butterworth, 1958. 320p., $9.50.)

TRANSATLANTIC TELEPHONE CABLE

The papers presented at the January 1957 joint meeting of the Engineering Institute of Canada, Institution of Electrical Engineers and American Institute of Electrical Engineers have now been issued in a bound volume. The eleven papers cover the design, manufacture and installation of the first transatlantic telephone cable, together with a discussion of the papers, and an index. (Ed. by W. K. Brasher. London, I.E.E., 1957. 125p., I.E.E. Procs., v.104, 1957 pt.B, suppl. no. 4.)

ECONOMIC AND SOCIAL IMPLICATIONS OF AUTOMATION: A BIBLIOGRAPHIC REVIEW

Over one third of the 610 references in this bibliography are annotated. In addition to general references and a list of bibliographies, the listings cover the following topics: manpower and employment; society and government; selection, training and job requirements; human relations; collective bargaining; management; office automation; case studies. The purely technical aspects of automation are not covered. (G. Cheek. East Lansing, Michigan State University, Labor and Industrial Relations Center, 1958. 125p., mimeog., $1.25.)

PARKING

A survey of the parking problem and possible solutions, this volume commences by discussing parking habits and needs. It then considers various types of parking—curb, metered and off-street, and the best arrangement of parking lots and garages. Statistics are quoted, and most of the material is illustrated with diagrams. There is a useful bibliography. (R. H. Burrage and E. G. Mogren. Saugatuck, Conn., Eno Foundation, 1957. 401p.)

°YEARBOOK OF THE HEATING AND VENTILATING INDUSTRY, 1958/59

This new edition contains papers on environmental radiation in winter and summer, ventilation problems associated with the use of radioactive substances, and the future of electricity for space heating, as well as an index to heating and ventilating literature published during 1957. A buyers' guide, a list of trade names, and manufacturers' addresses are given for those firms located in Great Britain. (London, Technitrade Journals, 1958. 422p., 12/-.)

THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: K. F. Tupper, M.E.I.C. — Treasurer: T. W. Eadie, M.E.I.C. — General Secretary: Garnet T. Page, M.E.I.C

Editor: Garnet T. Page, M.E.I.C.

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MARCH 1959

vol. 42 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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

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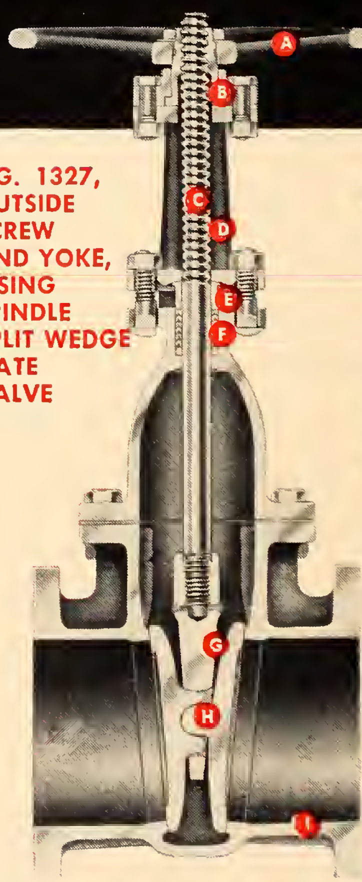

FIG. 1327, OUTSIDE SCREW AND YOKE, RISING SPINDLE SPLIT WEDGE GATE VALVE

- **A** High-Strength, Malleable Iron Wheel. Designed for firm, cool grip and easy operation.
- **B** Easily Renewable Yoke Bushing. Made of bronze for ideal thread engagement, with stainless steel spindle to prevent seizing or galling. Bushing of stainless steel optional.
- **C** Spindle. Long thread bearing surfaces with correct lead for easy, tight closing.
- **D** Yoke Bonnet. Liberal space between yoke arms for easy access to packing box. Precision machined flanged face assures uniform contact with gasket for a tight body-bonnet joint.
- **E** Two-Piece Gland. Gland flange and gland follower, eliminates binding of follower in case gland bolts are tightened unevenly.
- **F** Packing. Of chevron-type Teflon in large packing box. Prevents leakage.
- **G** Husky Wedge Carrier. Connects wedge to spindle, raises or lowers it.
- **H** Split Wedge. Ball-and-socket design automatically adjusts to tapered seating surfaces for positive shutoff.
- **I** Body. Through-port design for full, free flow.

STAINLESS STEEL SOLID WEDGE GATE

Fig. 1300, Screwed: Non-rising Spindle. 200 lb. 500°F.
Fig 1301, Flanged: 150 lb. 500°F. or 230 lb. 100°F.

STAINLESS STEEL GLOBE

Fig. 1308, Regrinding Bevelled Disc and Seat — Union Bonnet. 200 lb. 500°F.

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MEET THE AUTHORS

William Cumming Leith, M.E.I.C., mechanical Research Engineer, Dominion Engineering Works Limited, Montreal. *(Cavitation Damage of Metals).* A graduate of University of B.C. (B.A. Sc., mech., 1948, M.A. Sc., 1949). Mr. Leith is at present studying part-time for a doctorate degree at McGill University.

Since 1955, he has been engaged in the study of cavitation damage in diesel engines. For the past six years he has been in charge of the Mechanical Research Department at Dominion Engineering Works Limited. He is a member of the ASME Cavitation Committee on the standardization of magneto-striction testing.

J. E. Cousineau, P.Eng., M.E.I.C., Surveys Engineer, Hydraulic Section, Power Development Division, Quebec Hydro-Electric Commission, Montreal. *Some Aspects of Ice Problems connected with Hydro Electric Developments.)*

Graduating from the Ecole Polytechnique (B.A. Sc. civil, 1941), Mr. Cousineau was employed by the Quebec Streams Commission until 1948 when he joined the Quebec Hydro-Electric Commission serving as resident engineer on heavy construction. In his present position he is responsible for surveys in connection with the investigations of rivers for the establishment of storage dams and hydro plants.

During the course of his work he has had considerable experience concerning ice problems affecting hydro-electric developments and has devoted ten winter seasons to actual field observations.

L. A. C. Walford, M.E.I.C., (A.M.I. mech., E., Great Britain), Partner, Wiggs, Walford, Frost & Lindsay, Toronto. *(Power Requirements for Commercial Air-Conditioning Systems).*

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Mr. Beaulieu also attended the Sorbonne, Paris, where he studied mathematics and probabilities.

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Cover picture: Pipelaying through wheat fields near Moose Jaw, Saskatchewan.

CAVITATION DAMAGE OF METALS

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Cavitation damage of metals can be observed on a magnetostriction-type of accelerated cavitation machine with a Fastax camera taking 8000 pictures per second.

A brief description of the mechanism of cavitation is given with some typical examples of cavitation damage to machine parts in service. The magnetostriction apparatus which is used to compare the relative resistance of materials to accelerated cavitation damage is described. Weight loss variations and correlated bubble formation patterns on test samples are shown for a range of vibration amplitude, temperature, and pressure.

Cavitation damage of metals in diesel cooling systems can be reduced by controlling the dominant liquid characteristic (temperature, pressure or wettability) at a stabilized cavitation level while the increased metal resistance of stainless steel welded overlay on cast steel runners is more practical for hydraulic turbines.

CAVITATION IS A well known hydraulic phenomenon which may be associated with its destructive effects in hydraulic turbines and diesel cooling systems, although its advantages have been utilized in numerous ultrasonic devices such as flaw detectors, cleaning baths, and navigational echo-sounders. It should be emphasized that cavitation refers to the formation and collapse of vapour bubbles, while cavitation damage refers to the destruction of the guiding surface at the point of bubble collapse.

CAVITATION IS THE CAUSE

Cavitation can be described as a hydro-dynamic phenomenon which relates to the formation and collapse of vapour bubbles in a flowing liquid. These bubbles form in regions where the local pressure is reduced below the vapour pressure at that temperature; and conversely these bubbles start to collapse as soon as the local pressure increases above the vapour pressure. The mechanism of cavitation inception under measurable and reproducable conditions which are suitable for observation has been studied most successfully by Knapp[1] who correlated the measured history of an actual vapour bubble to the classical analysis of Rayleigh[2]. The collapse of a spherical bubble in an incompressible liquid was considered assuming isothermal compression, but neglecting viscosity and surface tension. The excellent agreement of the experimental results to the theoretical postulations confirmed that the kinetic energy of bubble collapse was absorbed elastically in the water and given back largely undiminished in the rebound effects. The formation of cavitation bubbles at vapour pressure conditions is common experience and it implies that water has no tensile strength, while the breaking strength of water between its molecular layers has been estimated by Frenkel[3] at 150,000 p.s.i.

CAVITATION DAMAGE THE EFFECT

Cavitation damage can be described as a conjoint action of mechanical-chemical effects, that is, a mechanical repeated stressing of a metal surface in the presence of several possible chemical reactions, a mechanism which is similar to corrosion fatigue. The separate, distinct impact force at the collapse of a cavitation bubble produces a stress concentration on a very small area, and may cause plastic deformation and strain hardening if the severity of cavitation attack produces a mean shearing stress greater than the yield strength of the metal. Severe plastic deformation can initiate etching of the grain boundaries without much actual removal of metal. Cavitation damage will proceed as a mechanical fatigue action, accompanied and perhaps accelerated by electro-chemical corrosion between the crystals in the plastically deformed area.

ACCELERATED VIBRATORY CAVITATION MACHINE

The need for rapid evaluation of metals resistance to cavitation damage has prompted the commercial application of the magnetostriction effect under controllable and reproducible conditions. The magnetostriction effect is a broad term applied to ferromagnetic materials which exhibit a change in physical dimensions when subjected to a magnetic field; or conversely, a change in magnetic properties occurs when the physical dimensions are altered by an external force. The most significant change is the 'Joule effect' or the change of length along the axis of the applied magnetic field when the field is varied. Nickel contracts in length at a decreasing rate in an increasing magnetic field until a maximum or saturation value is reached. All ferro-magnetic materials are temperature-sensitive, the material losing its magnetism as the temperature rises until the Curie point is reached, where all magnetic properties cease.

The magnetostriction apparatus consists of a high-frequency oscillator which produces a resonant longitudinal vibration of a nickel tube at its natural frequency when subjected to an alternating magnetic field. In the apparatus used by this author the nickel tube vibrates at 6500 cycles per second and each end has an amplitude of 0.0034 inch. The test button which is ⅝ inch diameter, is screwed into the lower end of the tube. The test button is immersed ⅛ inch in distilled water which is maintained at a constant temperature by a water bath. The tube is cooled by a water spray on the inner wall, and a vacuum aspirator removes the excess water from the bottom of the tube. The vibration amplitude is calibrated for some indicated output from the resistance strain gauge which is cemented on the vibrating nickel tube. Tentative specifications for a standardized vibratory cavitation test were proposed in 1956 by Robinson, Holmes and Leith[4], so that various laboratory tests results could be correlated to field experience.

Incubation Period

There appears to be an incubation period or a time interval at the beginning of each test during which considerable plastic deformation of the test surface takes place without any apparent weight loss. The incubation period is well defined for rolled metals and welded overlays, but not for cast irons. The incubation period is of great interest to designers of hydraulic machinery, especially for seal rings and turbine runners. The incubation period for rolled metals appears to have a linear relationship with the corrosion-fatigue limit of the metal. For a given metal, the incubation period is independent of the vibration amplitude, but the weight loss after two hours is dependent on the amplitude.

Cavitation Intensity and Vibration Amplitude

The effect of vibration amplitude on cavitation damage has been studied to determine approximate degrees of cavitation resistance for various metals. Figure 5 shows the vibration amplitude necessary for cavitation damage of welded stainless steel overlay type 308, which can be regarded as the threshold value of the metals resistance to cavitation attack. The

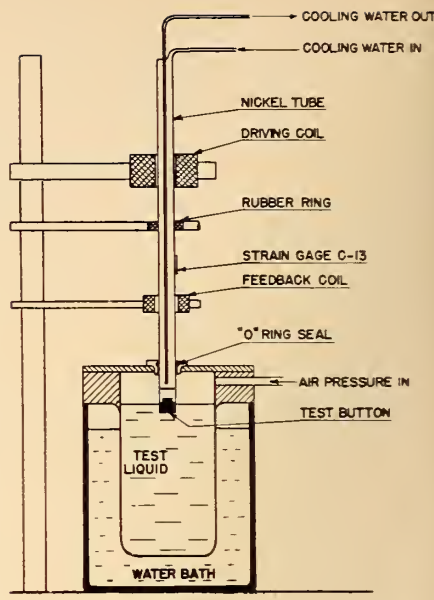
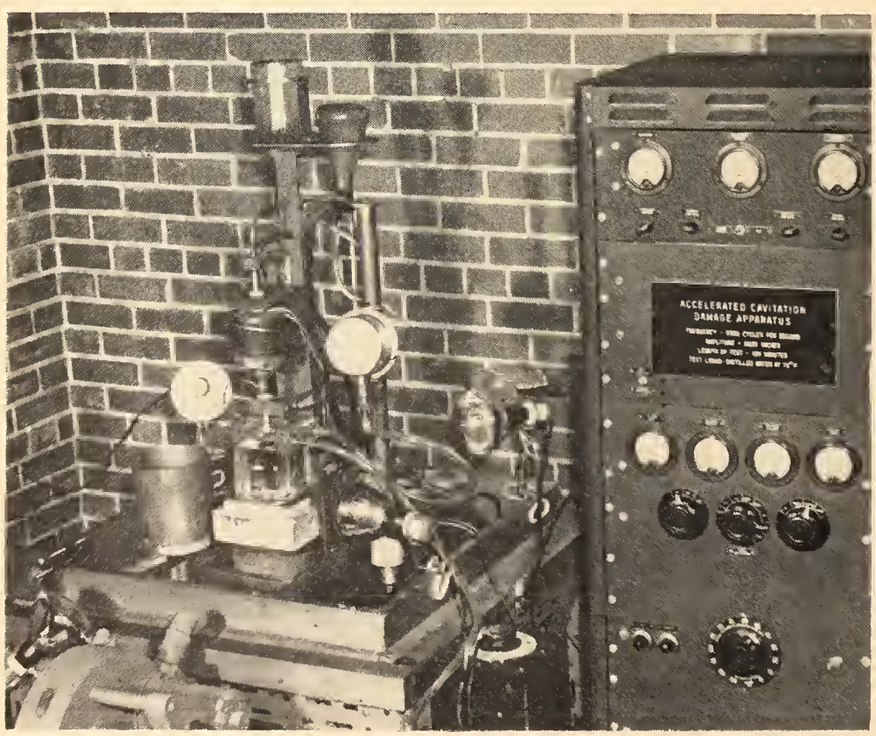


Fig. 2. Schematic diagram of nickel tube assembly.

effect of vibration amplitude on this magnetostriction apparatus can be compared to the effect of flow velocity in a water tunnel, since they both show the threshold value of the metals resistance, below which no metal is removed despite some plastic deformation, but above which the rate of metal-removal accelerates rapidly with increased cavitation intensity.

Fig. 1. Accelerated cavitation machine with Fastax camera.



HIGH-SPEED PHOTOGRAPHY OF CAVITATION BUBBLES

A Fastax camera, which takes up to 8,000 pictures a second on 16 mm. film, has been used to photograph the cavitation bubbles on the test button as it oscillates up and down in distilled water at 6500 cycles per second. The cavitation bubbles are usually viewed at the usual projection speed of 16 frames per second which slows down the action 500 times. The film is pulled past the aperature in a continuous motion and a rotating prism exposes each frame in turn. A Goose control unit provides the regulation of the camera speed, besides a remote control operation and synchronization of the camera with an event being studied. The unit acts as a time-delay mechanism to limit the camera voltage to 130 volts during the first 0.070 sec., and then releases the higher voltage necessary to obtain the higher picture rate. This time-delay action prevents tearing of the film perforations by the sprocket during the initial period of high starting torque. The central area on the test

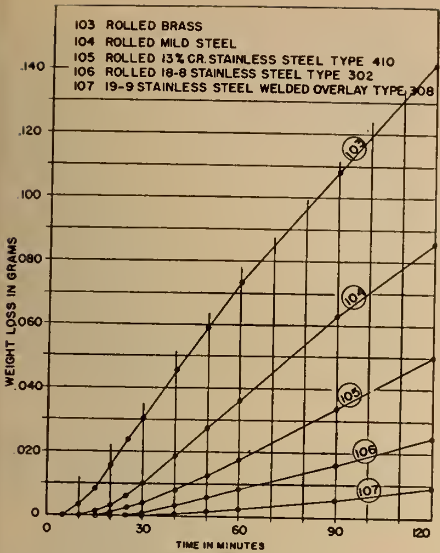


Fig. 3. Cavitation damage of typical metals.

button where the cavitation bubbles oscillate is the low-pressure zone during the upward motion of vibrating nickel tube, and the size of this central bubble pattern corresponds to the size of the damage pattern in all cases.

Effect of Vibration Amplitude

High-speed photographs of the cavitation bubbles show that only one central bubble forms at the low amplitude of 0.001 inch. As the vibration amplitude is increased to 0.003 inch, a continuous formation of small bubbles grows from the outer edge of the test button and these bubbles enlarge as they move radially to the central mass of oscillating bubbles.

Effect of Pressure

High-speed photographs of the cavitation bubbles show that the total area of the test button is covered by a blanket of oscillating bubbles at high vacuums near 0.5 p.s.i. absolute pressure. The size of this oscillating-bubble pattern is decreased as the pressure is increased, as the same work input is concentrated over a smaller area.

Effect of Temperature

High-speed photographs of the cavitation bubbles show that the bubble size increases with water temperature as expected by the decrease in the surface tension and the increase in the vapour pressure, but the cavitation damage is a maximum at 120°F where the maximum number of oscillating bubbles are observed.

CAVITATION DAMAGE IN HYDRAULIC TURBINES

Hydraulic turbines utilize the change of momentum of water as accomplished by the guiding surface of the runner vanes. The shape of these vanes is designed for specific operating conditions where the velocity of water is continuous across the flow area and cavitation is avoided by maintaining the local pressure at critical areas above the vapour pressure of the water. Since most hydraulic machinery is not operated continuously at the design conditions, metals with a high resistance to cavitation damage are used at critical areas. Cast steel runners with welded stainless steel overlay on the critical areas is common practice, since field repairs can be done in the turbine pit with a minimum of outage time. Stainless steel deposited by manual welding using stick electrodes 3/16 inch diameter require only one pass to provide sufficient metal for the 1/8 inch finished overlay thickness. Certified manual welding deposits stainless steel E308 with analyzed alloy contents of about 17% chrome and 9% nickel, and it deposits stainless steel E301 with about 16% chrome and 6% nickel as shown in Fig. 10.

Intensity of Cavitation Attack

Field experience with hydraulic turbines has provided three relative intensities of cavitation attack which have been based on the observed damages to the original cast steel runner, mild steel welded overlay and stainless steel welded overlay. The threshold value for each metal's resistance is considered to refer to a minor pitted condition after one year of operation, which would include the strain hardening and etching of the metal surface, without much actual metal removal.

(1) Minor pitting on the original cast steel runner.

(2) Severe pitting on the original

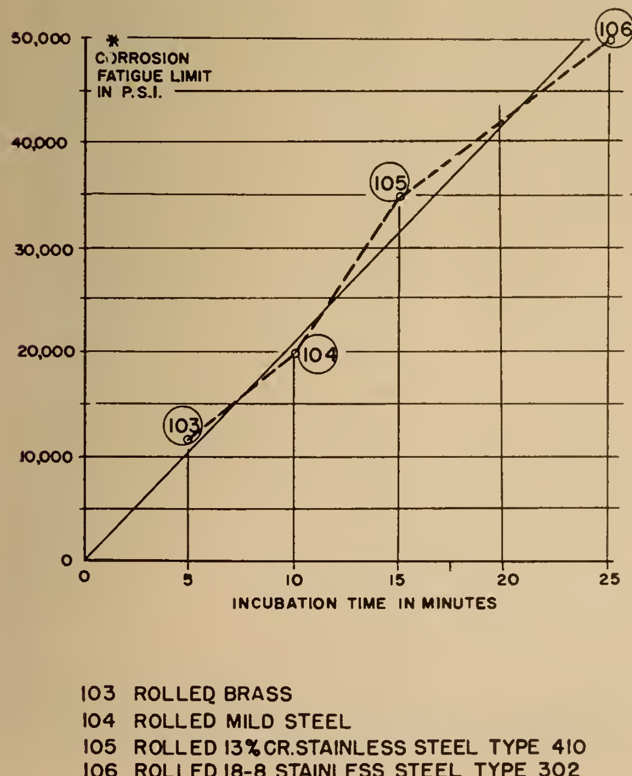
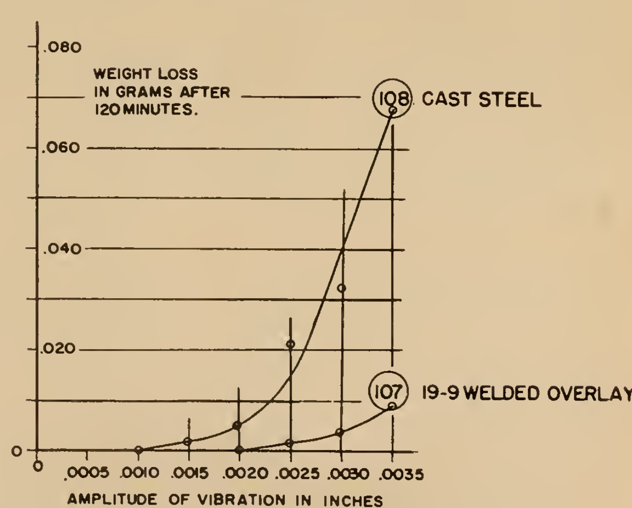


Fig. 4. Corrosion-fatigue limit and incubation time. See corrosion handbook.

Fig. 5. Effect of vibration amplitude.



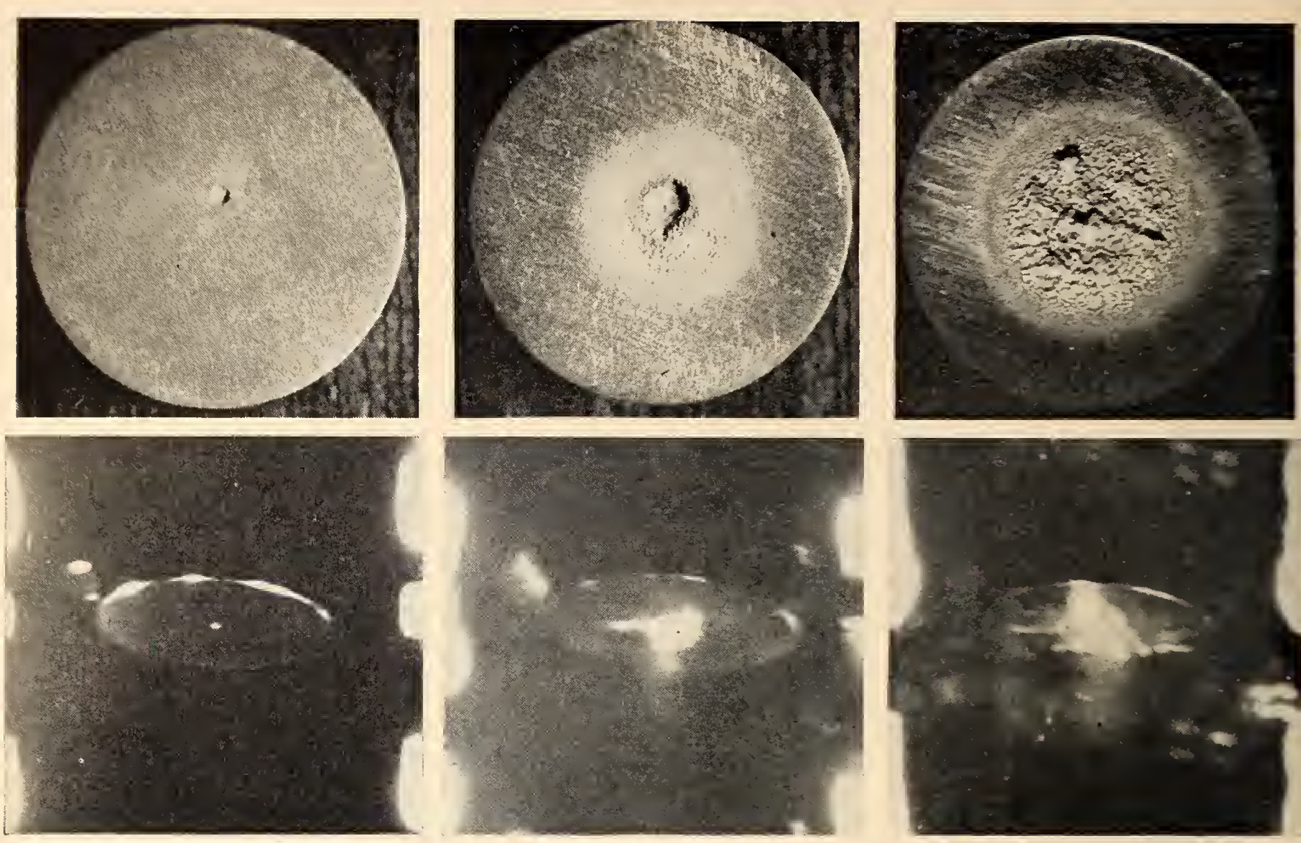


Fig. 6. Top, L. to R.: Amp.=.001"; Amp.=.002"; Amp.=.003". Damage patterns on test buttons.

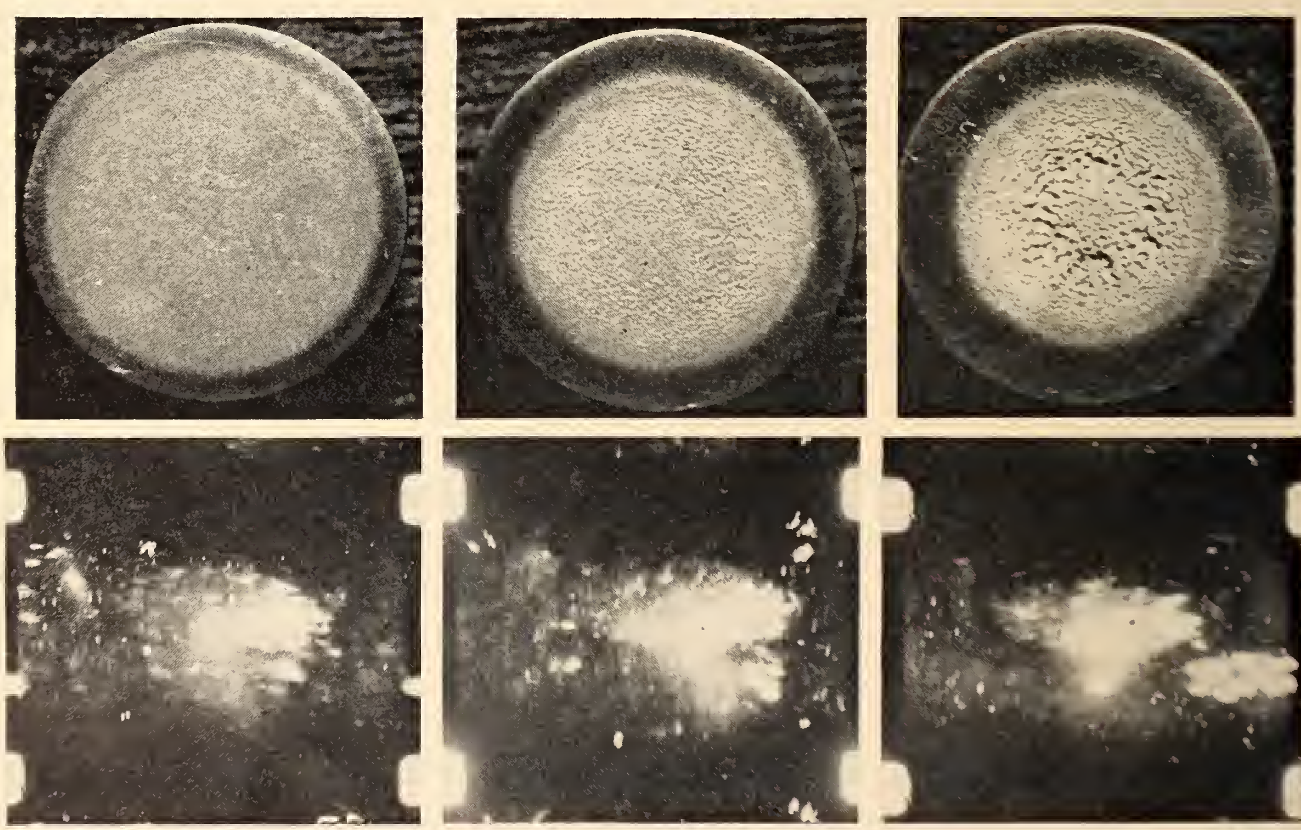
Bottom: Amp.=.001"; Amp.=.002"; Amp.=.003". Bubble patterns on test buttons.

High-speed photographs of cavitation bubbles at various vibration amplitudes. Speed: 8000 frames per second. Temperature: 76°F. Pressure: 14.7 P.S.I.A.

Fig. 7. L. to R.: Press.=5 psia; Press.= 7.5 psia; Press=10 psia. Damage patterns on test buttons.

Bottom: Press.=5 psia; Press.=7.5 psia; Press.=10 psia. Bubble patterns on test buttons.

High-speed photographs of cavitation bubbles at various pressures. Speed: 8000 frames per second. Amplitude: .0034 inch. Temperature: 76°F.



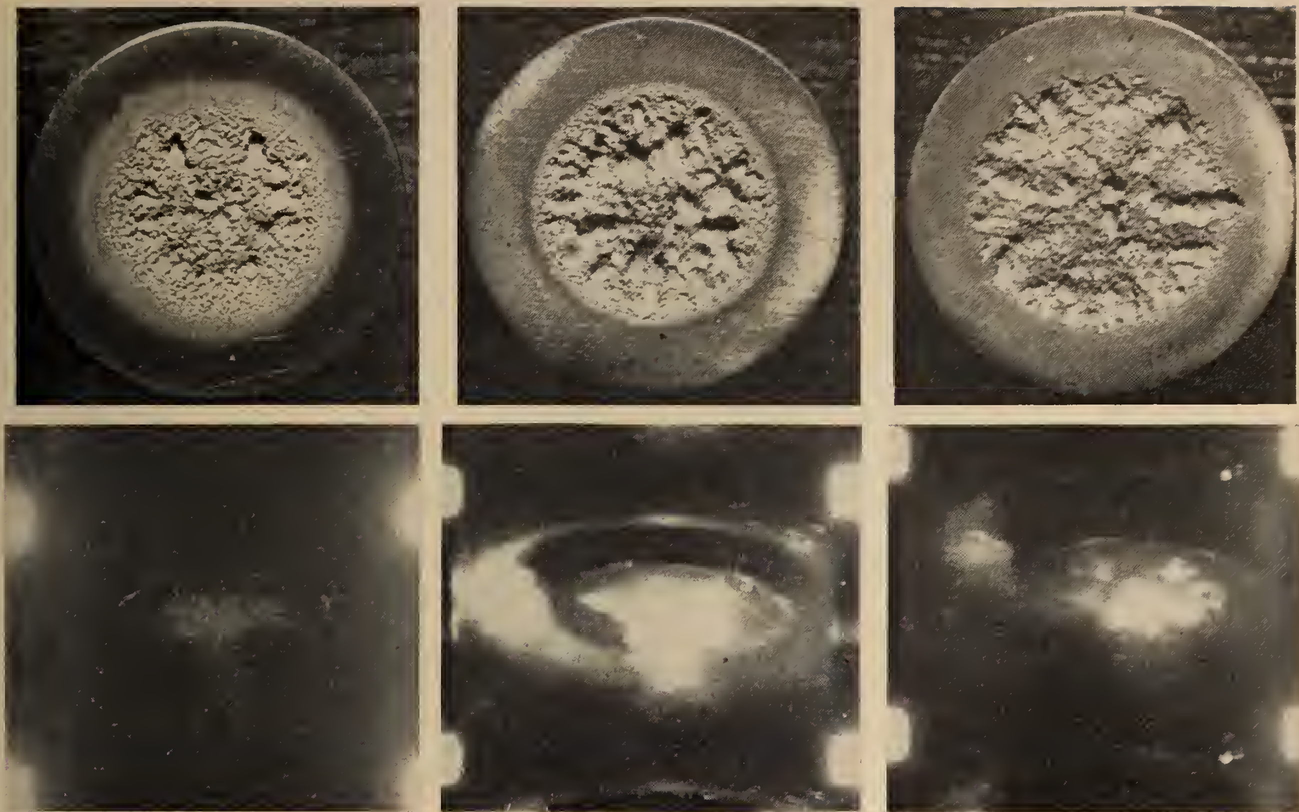


Fig. 8. Top: Temp.=70°F — Temp.=110°F — Temp.=150°F
Damage patterns on test buttons.

Bottom: Temp.=70°F — Temp.=110°F — Temp.=150°F
Bubble patterns on test buttons.

High-speed photographs of cavitation bubbles at various temperatures. Speed: 8000 frames per second. Amplitude: .0034 inch. Pressure: 14.7 P.S.I.A.

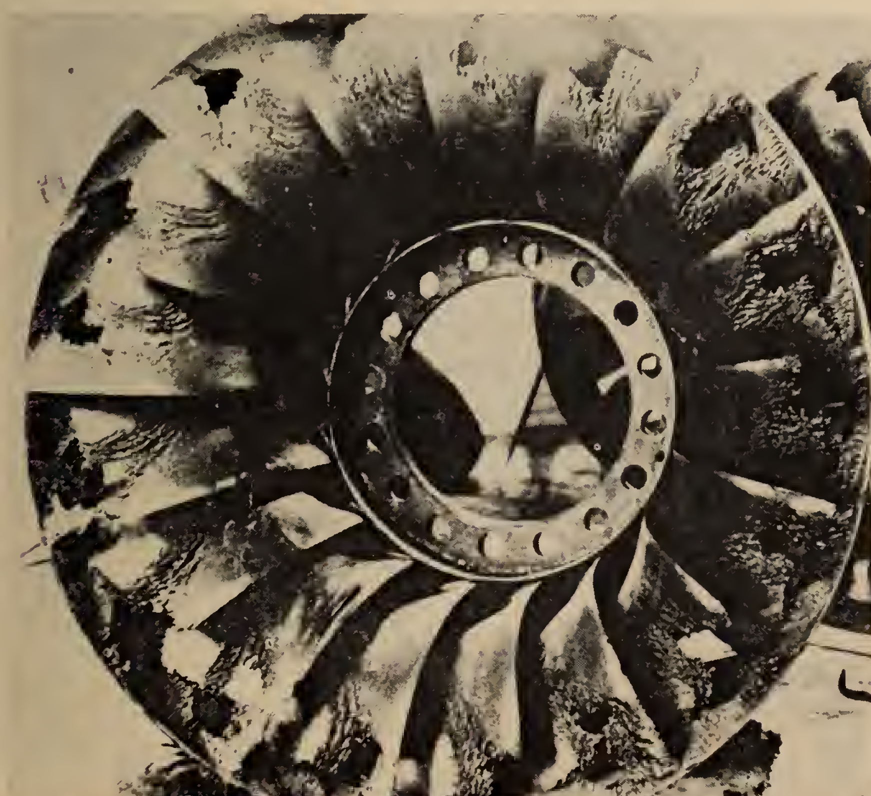
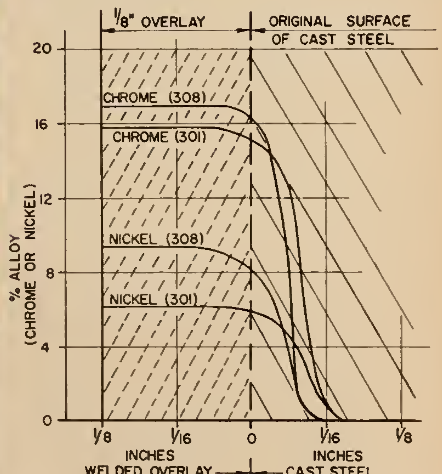


Fig. 9. A severely cavitated Francis-type hydraulic turbine runner.

Fig. 10. Alloy content of stainless steel welded overlays.



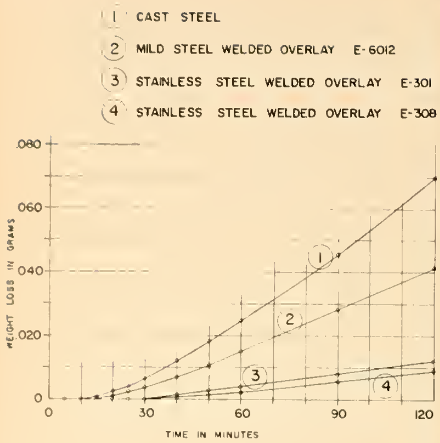


Fig. 11. Welded overlays for hydraulic turbine runners.

cast steel runner but minor pitting on the mild steel welded overlay.

(3) Severe pitting on the original cast steel runner and mild steel welded overlay but minor pitting on the stainless steel welded overlay.

Figure 11 shows the advantage of stainless steel welded overlay E308 for severe cavitation conditions.

CAVITATION DAMAGE IN DIESEL ENGINES

The modern diesel engine, especially for the competitive market in transportation facilities, has a water-cooling system which is designed to operate at increased but stabilized cavitation levels, and this requires higher liquid pressure and chemical additions to minimize the formation of cavitation bubbles. These chemical additions include corrosion inhibitors to prevent initial chemical pitting, detergents to eliminate foaming, and wetting agents to provide an adhering liquid film on the metal by depressing the surface tension at the liquid-metal interface. The recent design trends toward higher speed and increased thermal and mechanical loading in diesel engines has intensified the degree of cavitation damage, and many operators have reported that cavitation control by chemical additions is impossible to maintain without skilled workers.

Three instances of cavitation damage in diesel engines which have been corrected after extensive research are: (1) water-cooled cylinder liners; (2) water-cooled nozzle sleeves; (3) oil-lubricated connecting rod bearings.

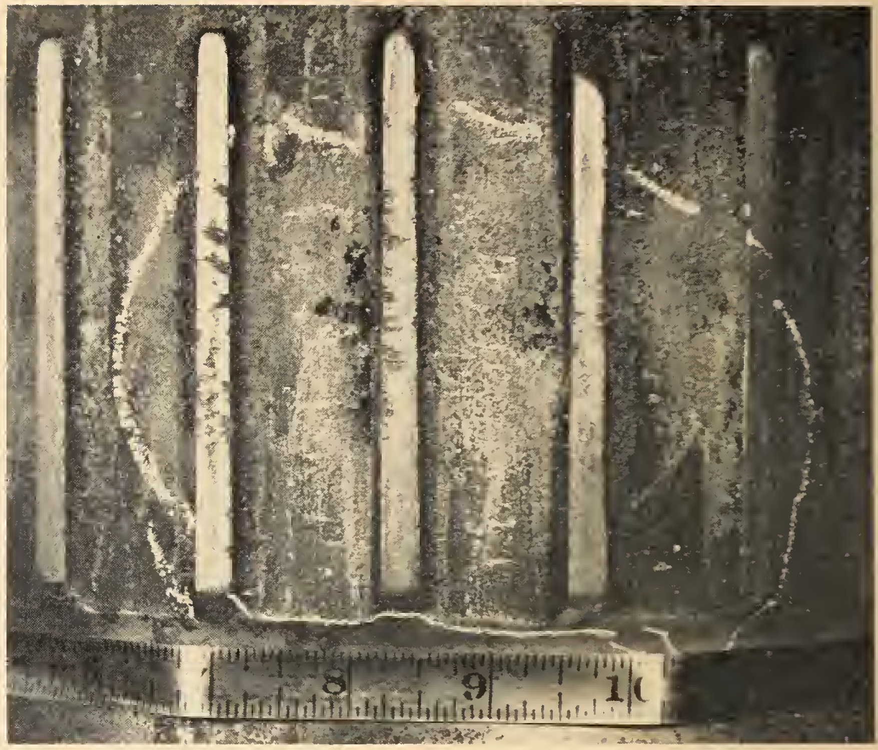


Fig. 12. A cavitated diesel cylinder liner.

Water-Cooled Cylinder Liners

Cavitation combined with corrosion in the water cooling system of diesel engines has caused unusual damage on the water side of alloy cast iron cylinder liners. The pitted areas have the typical honeycombed appearance of cavitation damage and they appear free of corrosion products. It had been usual to consider the internal wear as the major problem in cylinder liners, but chrome plating has extended the service life of the internal bore considerably. In some older diesel engines, the cylinder liner erosion was traced to unusually high water velocities at convergent-divergent water passages, where the locations of the water inlet and outlet were primary factors. The recent serious increase in cylinder liner erosion could not be

Fig. 13. Cross-section of a perforated liner wall.

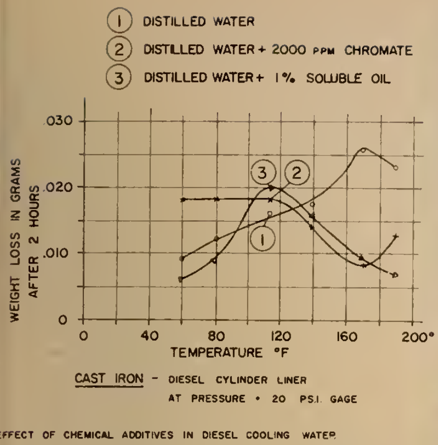


Fig. 14. Effect of chemical additives in diesel cooling water.

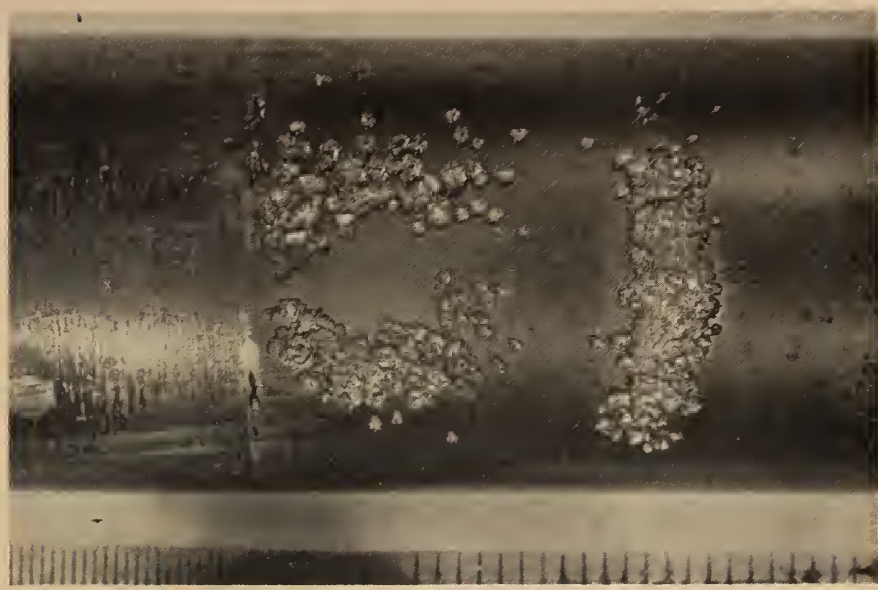


Fig. 15. A cavitated nozzle sleeve.

attributed to a flow condition, and further investigation revealed the presence of a major vibration problem. A vibration analysis revealed that pulsating vibratory forces from the piston side thrust were creating a forced vibration of the cylinder wall, similar to the ringing of a bell. The resonant vibration reaches a maximum amplitude at the middle of the water jacket, where the cylinder liner gets the least support from the engine block.

The worst pitted area is located on the water side of the liner exactly where the "side slap" of the piston takes place during the power stroke, which is 90 degrees from the crankshaft axis. The circumference of the liner vibrates with four nodes at 45 degrees from the crankshaft axis, and as expected, these areas are free from erosion. The side thrust from the piston distorts the liner into an oval shape, and the elastic properties of the cast iron permits the liner to vibrate alternately along the major axis and then the minor axis of the distorted elliptical shape.

Fig. 16. A cavitated connecting rod bearing.

Water-Cooled Nozzle Sleeves

Cavitation damage on the water side of bronze nozzle sleeves was noticed first in the Rocky Mountains where maintenance shops service diesel locomotives at 4,000 feet elevation above sea level. The nozzle sleeve is made of highly cavitation-resistant aluminum bronze, and is rolled into the cast iron cylinder head at each end. The eroded area appeared in a band around the sleeve on the discharge side of an annular flow passage where there was a convergent-divergent flow condition. Since the reduction of the atmospheric pressure at 4,000 feet elevation is about 10%, the cavitation problem was solved by increasing the back pressure in the pump return line by 5 p.s.i. On new diesel engines, the flow passage around the nozzle sleeve was corrected, and the increased back pressure in the pump return line is still recommended for diesel locomotives operating in the mountains.

Oil-lubricated Connecting Rod Bearings

In a reciprocating piston, there is a maximum side thrust on the crank pin bearing during the power stroke, which can cause oil separation on the unloaded side of the bearing. The cavitation bubbles can form in the low pressure zone at oil separation, and the bubbles collapse when the piston passes bottom dead-centre. Our test results show that the rate of cavitation damage is nominal as long as the lubricating oil is below 200°F., but the rate of cavitation damage accelerates rapidly above 200°F.

CONCLUSIONS

Diesel cooling systems remind us that vapour bubbles can be formed by cavitation and nucleate boiling although cavitation usually results from a pressure gradient and nucleate boiling usually results from a temperature gradient. Cavitation damage of metals in diesel cooling systems can be reduced by controlling the dominant liquid characteristics, (temperature, pressure, or wettability) at a stabilized cavitation level, while the increased metal resistance of stainless steel welded overlays on cast steel runners is more practical for hydraulic turbines.

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SOME ASPECTS OF ICE PROBLEMS

connected with Hydro-Electric Developments

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THE HARNESSING of streams located in a cold climate cannot be fully taken advantage of if curtailments of power generation result from adverse ice conditions. The rivers of Canada are exposed to a severe winter climate. In the Province of Quebec, the St. Lawrence River and its numerous tributaries forming the southern network of streams now undergoing intense hydro-electric development, present their quota of difficulties incurred because of ice conditions. This paper deals with some of the aspects of the various ice problems pertaining to some existing and proposed developments within this network.

Streams often differ considerably in their characteristics, among others, the temperature of the water has a great effect upon the ice formation and the seriousness of ice problems. The formation of ice or the presence of an ice cover over a stream is not necessarily an indication that the mass of water is at the freezing point. Some rivers are cooled down to the freezing point whereas others retain a good part of their heat content throughout the winter period. Streams that are cooled down to the freezing point are most favourable to the formation of the three main types of ice, namely: surface or sheet ice, frazil ice, and anchor ice. Hence, water temperature measurements are of utmost importance and should be the key move in tackling all ice problems.

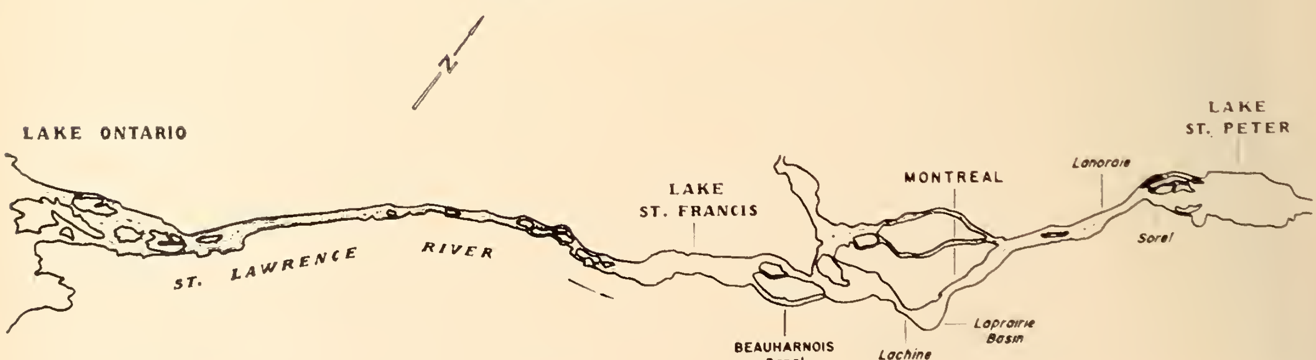
Firstly, the behaviour of a river whose mass of water is actually cooled down to the freezing point at the approach of winter will be discussed, then, briefly, the behaviour of a stream that does not cool down to the freezing point.

The freezing of the St. Lawrence River from Lake St. Peter to the foot of the Lachine Rapids, which occurs in very much the same way each year and offers a wide variety of phenomena, has been described by several authors. The following review is in the light of the present author's observations during the past ten years.

With the advent of cold weather, the water temperature in this stretch of the river gradually falls to the freezing point, and drift-ice appears over the surface. Sheet ice appears over areas of slack water, frazil forms in the more turbulent sections, and anchor ice grows in rather shallow but fast water. Slush-ice may also occur, depending on weather conditions. Owing to the fast current of the river, these ice flows are carried downstream into Lake St. Peter and there come to rest at a section near the lower end where the average velocity of water is from 1.0 to 1.25 feet per second. The converging shores at the outlet of the lake and the low velocity of water together with the water at the freezing point as well as the favourable weather conditions combine to form an ice bridge from which the ice-pack starts its travel up-stream. A packed ice cover then extends all the way up to the foot of Lachine Rapids covering the entire water surface.

The cover which forms over gently flowing sections, as in the case of Lake St. Peter, is relatively smooth; that is to say, only slight telescoping takes place as the drifts of ice pack up-stream. Thence, the cover becomes

Map of the St. Lawrence River.



more and more rugged as it extends over a faster current (Fig. 1). When the pack reaches a section of the river where the velocity becomes so high that the drift-ice is carried under the cover, a "hanging dam" forms. Such sections are found in the narrows at the head of Lake St. Peter and opposite Lanoraie, as well as in the Harbour of Montreal and at the foot of the Lachine Rapids. While a hanging dam is in the process of formation, backwater is created in front of the pack. The effects of this are a raising of the water level up-stream as well as an increase of the cross-sectional area of the river and a corresponding decrease of the average water velocity. According to this process the pack has been observed building upstream in sections of the river flowing at a rather high velocity. Even the Lachine Rapids were nearly surmounted by the pack on two occasions in the course of the past three winters, which is a phenomenon of recent occurrence.

Thus, from the outlet of Lake St. Peter to the foot of Lachine Rapids, smooth ice covers, rugged packed ice covers, and hanging dams alternate with one another. The passing of the pack at a certain point is characterized by a raising of the water level as the pack approaches the point and then a lowering of the water surface after the pack has passed. When a series of shoves occurs (i.e., when the pack advances and recedes, passing the same point many times during the formation and consolidation of a hanging dam to its full size) the water level at that point fluctuates giving the hydrograph a saw toothed form. It is possible to determine the time at which the pack has passed a point by examining the hydrograph for that point. The size to which a hanging dam will grow is dependent on the average velocity that the pack must overcome to travel up-stream without ice being carried under the cover, and this velocity is influenced by the weather conditions.

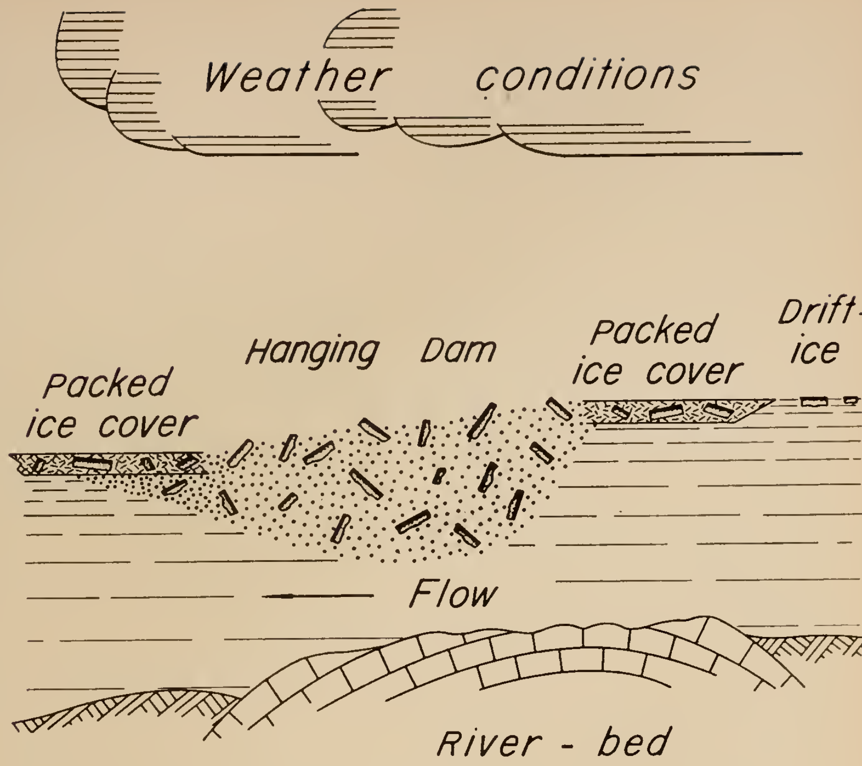


Fig. 1

The maximum average velocity against which an ice cover will pack up-stream without ice being carried underneath has been established, for all practical purposes, at 2.25 feet per second. It must be emphasized that the term maximum average velocity infers the existence of ideal conditions which may be defined as follows: the temperature of water must be at the freezing point and the atmospheric temperature down to at least zero degree Farenheit or better still sub-zero weather prevailing. Any departure from such ideal conditions must be associated with a lower average velocity. Therefore, the travel of the pack up-stream without ice being carried underneath is not governed by the average velocity of water alone; although the latter may well be under 2.25 feet per second, nevertheless a hanging dam will form. The more remote the departure is from ideal conditions, the lower the average velocity will be that the pack can overcome and the larger the hanging dam required to provide the lower velocity. As a matter of fact, the largest hanging dams and the highest water elevations in this stretch of the St. Lawrence River are associated with the milder winters and not with the colder ones. As evidence, Figs. 2 and 3 show the advance of the pack along the same stretch of the St. Lawrence River extending from the head of Lake St. Peter up-stream past Lanoraie but under different conditions.

In the first instance, namely, under ideal conditions, the pack advanced a distance of 25 miles in one day, i.e. from December 29th to the 30th of the 1947-48 winter freeze-up period; the temperature of water was at the freezing point and sub-zero weather prevailed. Under such circumstances the pack made fast progress and the ice cover that formed consolidated rapidly. Although ice forms more readily under ideal conditions, it must be realized that once a cover is formed, the latter acts as an insulator in preventing further formation of ice save for the growth of the cover itself. The result is that less ice will form and the slopes will be smoother if the freeze-up occurs under ideal conditions.

In the second instance, namely, under the most adverse conditions, the pack advanced along the same stretch of 25 miles but this time the journey took 21 days, i.e. from December the 30th to January the 20th of the 1948-49 winter freeze-up period; the temperature of water was at or very close to the freezing point but the atmospheric temperature was well above the zero mark most of the time. Large quantities of ice formed and packed, but as the cover could not consolidate on account of a marked departure from ideal conditions, a series of shoves occurred. The pack advanced and receded many times; the hanging dam grew larger and the slope became steeper than it did in the first case.

It is obvious that, under ideal conditions, a packed ice cover will form and consolidate more readily and that the pack will advance against a higher average velocity. The departure from ideal conditions may be brought about chiefly by a rise in atmospheric temperature or by a rise in water temperature or by both at the same time. In a stream where the mass of water is actually cooled down to the freezing point at the freeze-up period, it is almost invariably the rise in atmospheric temperature that brings about the departure from ideal conditions, the temperature of water remaining at the freezing point. Hence, the rate of formation and consolidation of the ice cover is dependent on the daily degree-days below the freezing point. Likewise ,the average velocity against which the pack can travel up-stream, forming a relatively smooth ice cover is subjected to the degrees of frost. Hence it is that during freeze-up period a hanging dam may form at a section where the average velocity of water is well under 2.25 feet per second.

The author has made an analysis of the data obtained on ice conditions of the St. Lawrence River over the nine winter-periods previous to 1952 and has endeavoured to show that an atmospheric temperature of 20° F. is very close to that at which the formation of ice or the growth of the ice cover is at a standstill, and consequently, that at least 12 degrees of frost are required at all times during the winter to ensure the stability of the ice sheet.

The amount of ice formation depends on the amount of heat liberated by the water. Therefore, the temperature gradient between the water surface and the atmosphere is by far the most important factor in producing ice. Hence, the number of degree-days below the freezing point in any period will be the measure of the quantity of ice formed. When the temperature of air is above the freezing point, heat passes from the air to the water. Heat is then absorbed by the water with a reduction in the proportion of ice. The amount of ice thus lost is also measurable by the degree-days above freezing.

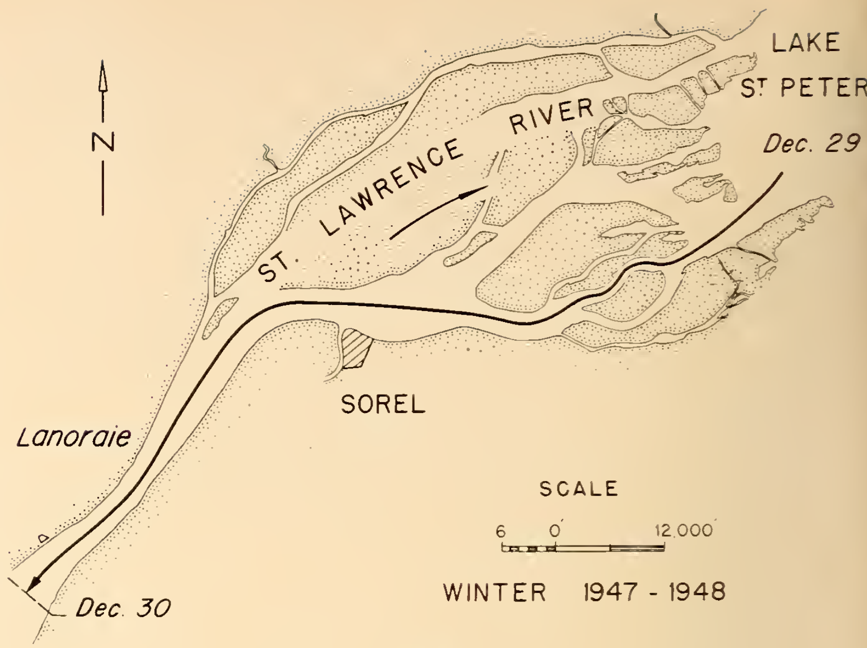


Fig. 2

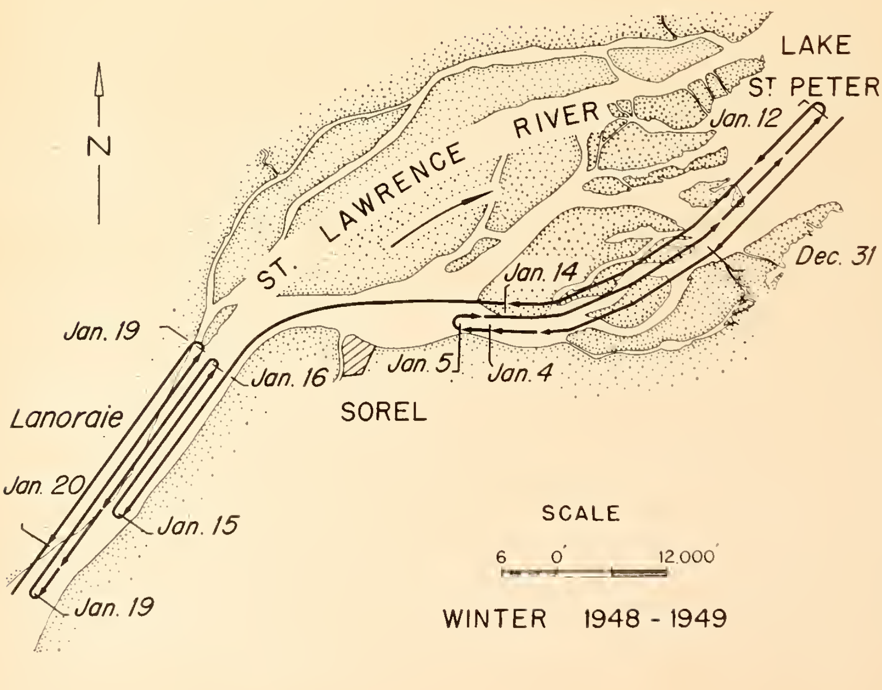


Fig. 3

Once an ice cover has formed and has consolidated to some extent, it is often advisable that pertinent information be made available with regard to its stability, especially at the beginning of the winter period. For such purpose a graph has been devised that can easily be prepared from day to day showing at a glance the stability of the cover (Fig. 4). According to the way the graph is prepared, it is of best value during the early stage of the winter season.

The graph shows the accumulated average of the degree-days from the date the ice cover formed. The only data required are the daily degree-days with reference to the freezing point with which the cumulative degree-days are obtained, and the accumulated average worked out daily from the date the cover is formed. The diagram indicates along the X-axis the period from the day the ice cover formed until the day the break-up occurred, and along the Y-axis the accumulated average of the degree-days. The horizontal lines limit the regions of ice cover conditions. When the accumulated average of the degree-days is above 15 the stability of the cover is good; when the average falls between 15 and 12 the ice cover conditions become fair; when the accumulated average drops to and below 12, shoves and even a break-up are most likely to occur. Hence, open water conditions are back when the average is down to 10. The application of this formula will give reliable indications provided that the average velocity of water at freeze-up was low enough to allow the cover to form quickly and without ice being carried underneath under prevailing conditions, and that the velocity after consolidation of the cover does not exceed 2.5 feet per second.

On streams that are cooled down to the freezing point at freeze-up period, base-load hydro plants located so that they must use the flow as it comes without being able to store any of it must be provided with a fore-bay of sufficient cross-sectional area to ensure a flow unhindered by adverse ice conditions, thereby averting the possibility of floods up-stream and a loss of head at the plant.

Of course, there may exist some natural or artificial features to safeguard a run-of-river plant against flooding up-stream when a loss of head occurs at the plant due to a hanging dam forming in the forebay. Such features may consist of a very large lake, say, the size of Lake Ontario on the St. Lawrence River or a proportionally smaller lake on a smaller stream, near the forebay and at the same elevation. In this instance, the reduction in flow due to the formation of a hanging dam would not suffice to raise the lake by an appreciable quantity before the winter period is over. Also a diversion channel, similar to that which by-passes the Beauharnois Canal, could provide an effective safety-valve.

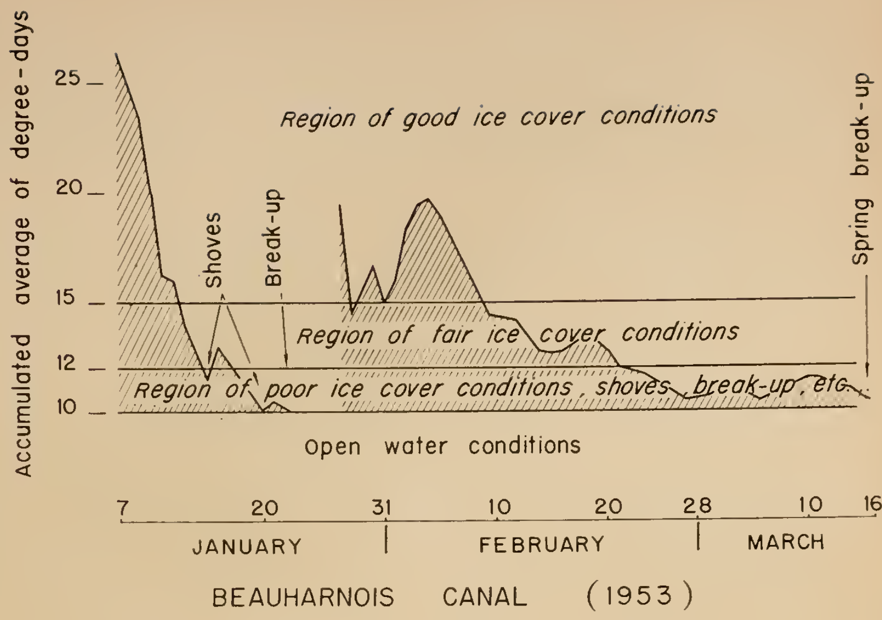


Fig. 4

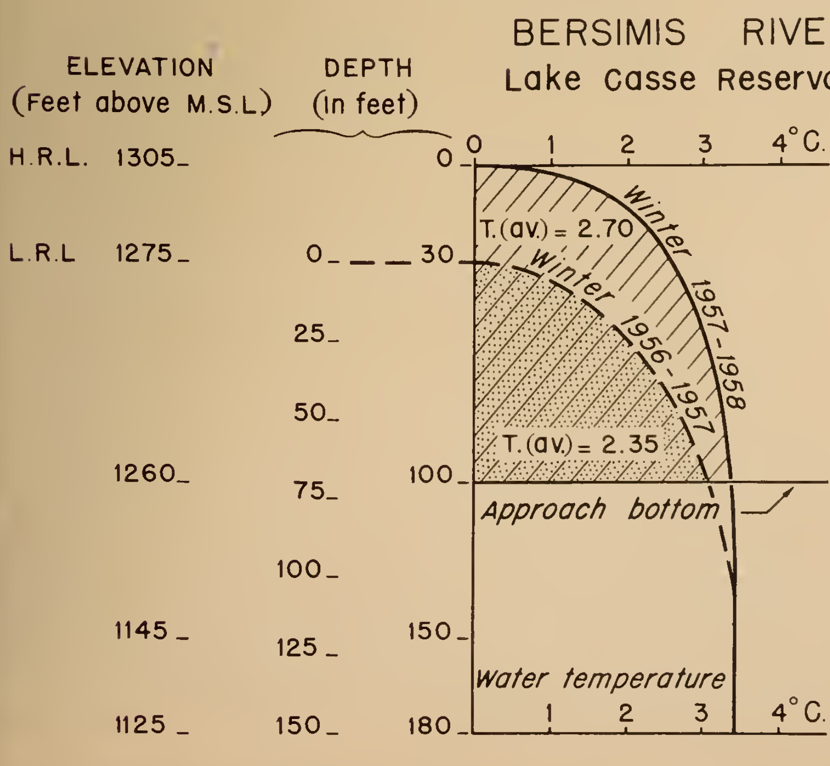
On the other hand, in the Lachine Section of the St. Lawrence river a base-load run-of-river plant would be provided with a sea-like lake capable of cushioning a rise in water level but could be provided with a by-pass. Here the flow must pass as it comes and consequently ice conditions obviously would be a big problem unless sufficient cross sectional area could be provided in the forebay to permit the formation of a smooth packed ice cover.

As previously stated, a stream whose mass of water is actually cooled down to the freezing point is most likely to accelerate the formation of all types of ice. The Lachine section is typical of such a stream. Ice could not be disposed of simply by letting it run through the plant, as an operation of this sort would soon clog the openings. Besides, a good ice cover must be formed and held up-stream to prevent further ice formation and avoid the recurrence of ice jams downstream in the Laprairie Basin that would flood the tailrace and drown out the units. This danger will always be present as long as the St. Lawrence river is allowed to freeze over below Montreal Harbour.

In this connection I fully concur with the opinion of Mr. Herbert L. Land, chief engineer of the St. Lawrence Ship Channel, who told a meeting of the World Ship Society (27 February 1958) that "Winter navigation in the St. Lawrence River inasmuch as the ice has run all the way to tide-water will not be possible for a long time to come with existing methods of combatting the ice menace".

A smooth packed ice cover is unquestionably the best protection with

Fig. 5



which a plant can be provided against ice troubles. A good ice cover on a forebay puts an end to the formation of ice of all types save of course, for the growth of the cover itself; it acts as an insulator. In the light of observations carried on the St. Lawrence River in the Soulanges and Lachine Sections, and also below the Lachine Rapids downstream to the head of tide-water, the cross-sectional area of the forebay at Lachine should be such that the average velocity of water would not exceed 1.5 feet per second at freeze-up period and 2.5 feet per second after the cover is well consolidated and until Spring break-up.

Such velocities may seem low but it must be borne in mind that in this particular section of the river: firstly, the temperature of water actually drops to the freezing point; and secondly, ideal conditions seldom exist at freeze-up time, though, if this is the case at the beginning, such conditions rarely prevail throughout the freeze-up period.

When conditions are such that even under a velocity of 1.5 feet per second the ice cover will not advance nor consolidate, then the chances are that the drifts of ice may run freely through the plant. But when a cover will form readily under a velocity of 1.5 feet per second or higher, then the disposal of ice through the plant becomes more and more hazardous as the velocity increases. In the author's opinion, the use of heat and compressed air to prevent trouble from ice cannot be relied upon in so mighty a river as the St. Lawrence.

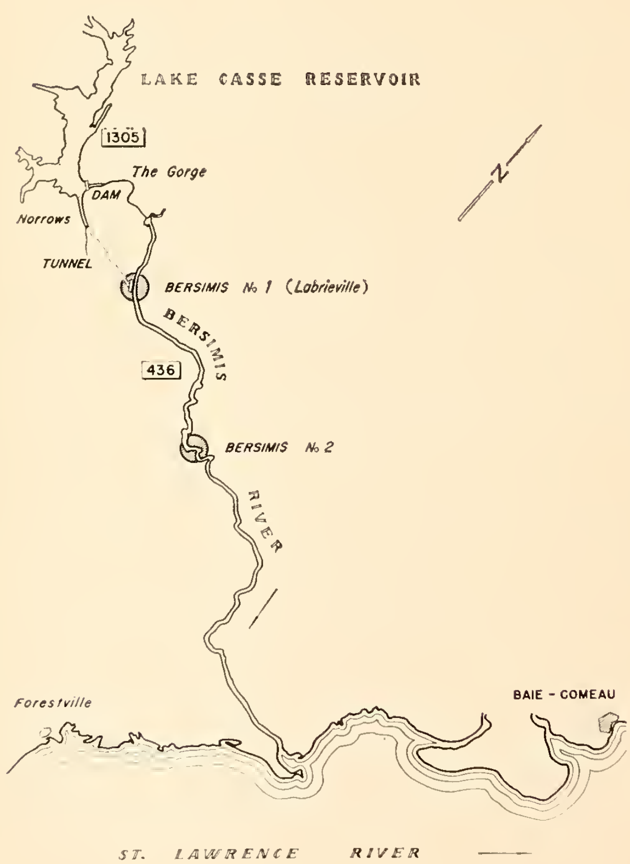
In contrast to the St. Lawrence River the Bersimis River, a tributary of the St. Lawrence flowing into it between Forestville and Baie Comeau on the North Shore, is to a great extent never cooled down to the freezing point.

Under natural conditions, the Bersimis river appeared in winter like any other stream covered with an ice sheet save for a few open rapid stretches. Its development called for the establishment of two power plants Bersimis No. 1 and No. 2. The design of Bersimis No. 1 required an eight-mile supply tunnel by-passing a nine-mile gorge plus an eight-mile stretch of the river, whose intake was located on a tributary stream the Desroches river. The valley of the latter forming the approach to the tunnel provided a restricted section for the flow. At first sight velocities were found unduly high and consequently a certain volume of excavation was deemed necessary for the following reasons: (a) to reduce the loss of head; (b) to prevent erosion of the banks and ensuing pitting of turbines.

As regards the formation and maintenance of a probable ice cover, precise water temperature measurements were the key move. They were taken during the winter period 1952-53 when the river was still under natural conditions and brought to light the fact that at the head of the gorge the temperature of water of the Bersimis River never dropped to the freezing point, but averaged during the coldest winter months from 0.10 to 0.37 of a degree Centigrade above the freezing point. Nevertheless, an ice cover formed from the head of the gorge up-stream. The ice cover was tested and found to be very poor, hardly strong enough to support a man and dotted with small air holes. It is noteworthy that this river, lying between the 49th and 50th parallels of latitude, where the winters are without doubt much longer and colder, was never cooled down to the freezing point. This is indeed one special feature that accounts for the large difference in ice problems encountered from one river to another.

Furthermore, No. 1 development called for the creation of a reservoir from the head of the gorge up-stream which meant raising the level of the river by 160 feet (from elevation 1,145 to elevation 1,305 above mean sea level). The mass of water would then lose its turbulence and also its uniform temperature to assume the water temperature gradient characterizing deep quiet waters. That is to say, the upper layer of water would undoubtedly be cooled down to the freezing point and then the temperature of water would be warmer with depth, tending towards a temperature of 4° C. near the bottom, at which temperature water attains its maximum density. As the reservoir was to be created along a river and lakes having rather steep banks, the resulting storage was relatively deep in proportion to the area. These conditions were most favourable to the conservation of a good part of the heat content in the mass of water. As a matter of fact, subsequent water temperature measurements effected at various reservoir elevation have indicated that the higher the water elevation, the higher the temperature of water (Fig. 5).

At a reservoir elevation of 1,275, the upper layers of water entering the approach to the tunnel averaged 2.35 deg. Centigrade while at full reservoir elevation of 1,305 it averaged 2.75



Map of the Bersimis River.

(Continued on page 88)

POWER REQUIREMENTS FOR COMMERCIAL AIR CONDITIONING SYSTEMS

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Wiggs, Walford, Frost and Lindsay, Consulting Engineers

IT IS NOT MUCH over a quarter of a century since the vogue for air conditioning entered this country. Hardly had it been properly introduced, when the second phase of world conflict put a stop to its infant growth. Even in the first few years after 1945, the number of air conditioning installations could not be called large, but of recent years the growth of the industry may be termed phenomenal. Not only is a large proportion of the commercial structures being built with integral conditioning but many existing buildings are now being equipped with this amenity to comfort.

Apart from the effect of this on the air conditioning industry, both as to the manufacturer of equipment and the installer, it affects very closely the electric generation and distribution authorities, financial institutions, and the municipalities in so far as water treatment and distribution systems, and sewage and drainage collection and disposal are concerned.

It is the purpose of this paper to examine the electrical load imposed by air conditioning, and it is to be understood that the remarks are confined to commercial air conditioning systems, that is, those systems which are installed, in the main, to provide creature comfort. Industrial systems are another matter entirely, and beyond the scope of this paper.

In approaching this subject, it has been considered that it would be found interesting to know something of the factors which contribute to the total electrical load, something of the magnitude of this load and something of the current consumption during operation.

The term *air conditioning* is perhaps one of the most frequently misused terms in the English language. The definition of *air conditioning* to be found in the Guide of the American Society of Heating and Air Conditioning is "It is a process by which simultaneously the temperature, moisture content, movement and quality of the air in enclosed spaces intended for human occupancy may be maintained within required limits." In this definition the word "simultaneously" is most important; there are many installations which perform only some of the duties enumerated. These are not air conditioning systems in the fullest sense of the word.

If temperature and moisture are to be controlled within required limits, it is fundamental that in periods of high external temperature and relative humidity a capacity to cool and dehumidify is required and in periods of low external temperatures a capacity to heat and humidify is required. This is true only to a certain degree, since it will be readily understood that the effect of the external temperature is of significance only at the skin of the building, that is, at the side walls and the roof. Provided the effects of external variations in temperature are offset at the places where they occur, their effect on the internal spaces of the building is nil and the load in these spaces is always a cooling load. This internal cooling load is dependent upon:

1. Density of human occupation.
2. Lighting intensity.
3. Machine load.

To derive the total cooling load of 1,000 sq. ft. of office space the following design data have been assumed:—

Outside dry bulb	95°F.
Outside wet bulb	75°F.
Inside dry bulb	74°F.
Inside relative humidity	45%
Lighting	4 watts/sq. ft.
Occupancy	12 persons/1000 sq. ft.
Exterior wall factor	0.16 B.t.u./sq. ft./deg. difference
Double glazing	0.65 B.t.u./sq. ft./deg. difference
Fenestration	30%

An area of 1,000 sq. feet will accommodate twelve people comfortably, which represents, since it is assumed that these people are moderately active office workers, a sen-

In approaching the subject, it has been considered that, since air conditioning requires the use of considerable quantities of power, it would be found interesting to discuss the factors of a system which contribute to the electrical load, and useful to know something of the magnitude of the load and something of the current consumption during operation.

In this paper has been brought together the substance of two lectures given before the Canadian Electrical Association and the Montreal Chapter of the American Society of Heating and Air Conditioning Engineers.

sible cooling load of 2,400 B.t.u. per hour and a latent cooling load of 3,000 B.t.u. per hour.

To obtain what is considered to be good office lighting to-day requires about 4 watts per square foot and creates a cooling load of some 13,600 B.t.u. per hour.

The use of electric office machines is now almost universal. This is of the order of 0.7 watts per square foot and imposes a further cooling load of about 2,400 B.t.u. per hour.

These loads constitute what is known as the internal heat gain and are present at all times when the building is occupied. Their total is 21,400 B.t.u. per hour or 1.78 tons refrigerating effect.

Outside air for ventilation purposes is required for the comfort of the occupants of the space, a reasonable quantity for each office worker being 20 c.f.m. This air must be warmed or cooled as dictated by the outside conditions prevailing at the time. When outside conditions are at the design dry and wet bulb temperatures there is a quantity of about 1,000 B.t.u. per hour per person of heat present which must be removed. This cooling load is variable from day to day over the cooling season, but the peak for any particular project is reached when the design conditions laid down are attained.

Now if the 1,000 sq. ft. of office space under consideration is rectangular, having an exterior wall of 20 feet by 13 feet high, with westerly exposure, and an interior depth of 50 feet, the cooling arrangements must compensate for the heat transmitted through the window and wall structure by reason of the difference between the inside and outside dry bulb temperatures and the heat transmitted through the glass by solar impact. This quantity of heat will be of the order of 8,000 B.t.u. per hour and will depend on a number of circumstances; ratio of glass area to exterior wall area, wall construction or orientation of the building, outside shading and inside shading, among others.

The total of these two variable quantities, i.e. ventilation load for 12 persons and external load, is of the order of 20,000 B.t.u. per hour or 1.66 tons refrigerating effect.

BUILDING	A	B	C	D	E	F	G	H	J
RATIO NETT. TO GROSS AREA %.	72·5	77·22	73·2		65·64		68·55	70·25	63·23
TONS PER 1000 SQ. FT. NETT.	3·30	3·07	3·25	3·26	3·00	4·09	3·44	3·85	3·17
HP/1000 SQ. FT. NETT.	6·30	7·01	6·45	5·04	5·45	7·29	4·95	6·03	5·07
HP/1000 SQ. FT. GROSS.	4·55	5·41	4·72		3·58		3·40	4·24	3 21

Fig. 1.

For the hypothetical area of 1,000 square feet under consideration, therefore, the total cooling load is

Internal load	1.78 tons
Ventilation and external load	1.66 tons
A total of	3.44 tons

If the structure has only one floor then a roof load of about one half ton must be added for a net area of one thousand square feet.

It is to be noted that the whole of the 1,000 square feet has been considered to be air-conditioned space. In dealing with a building however, it is extremely unlikely that the whole of the space enclosed by the exterior walls will be air conditioned. The gross area of a building is that of the superficial area of the ground upon which it stands multiplied by the number of floors. The net conditioned area is the total area of the conditioned spaces within the building. Over a number of buildings the ratio of net to gross area can vary considerably as may be seen in Fig. 1.

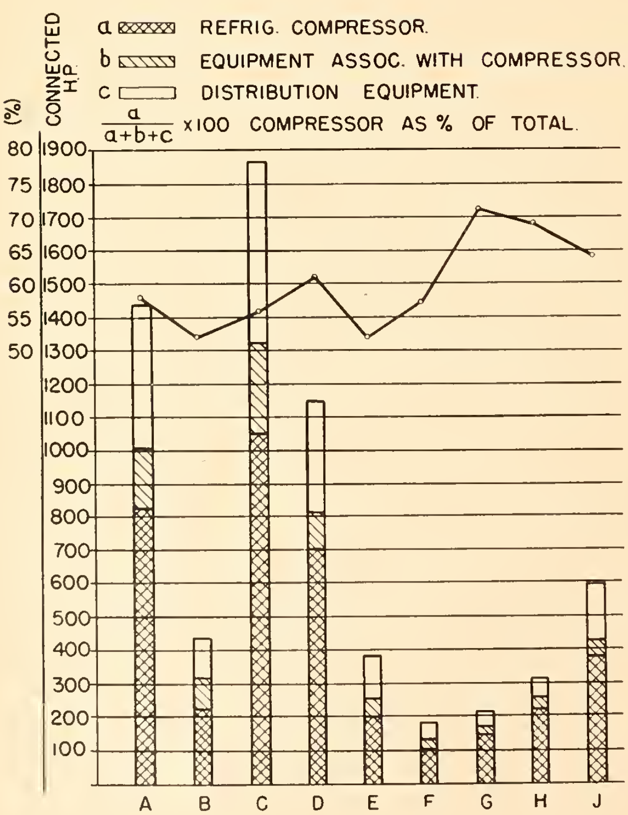
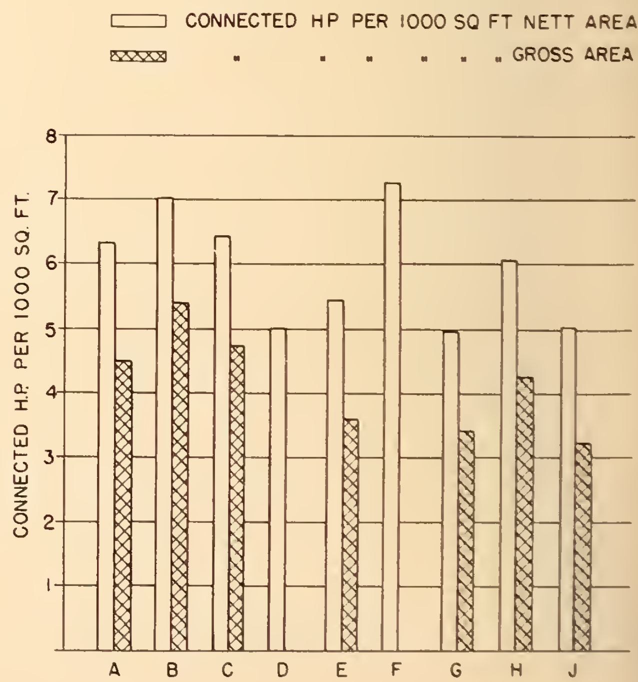
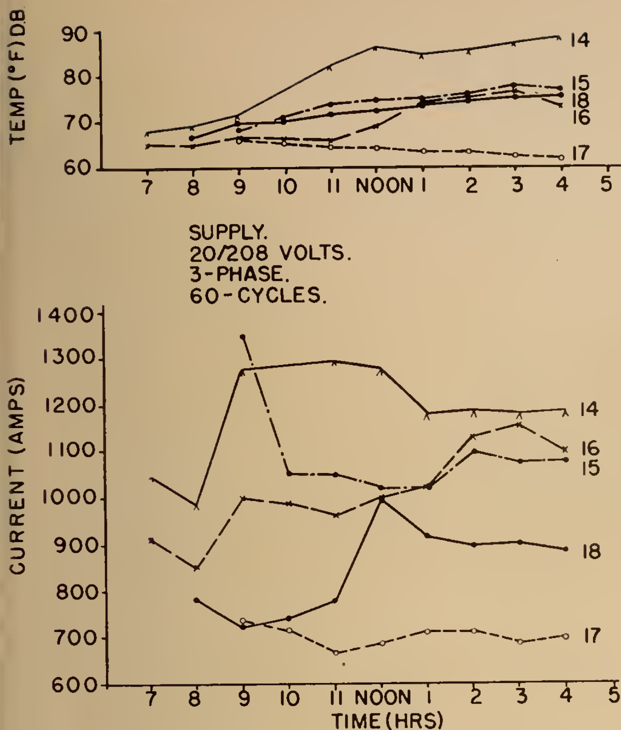


Fig. 2. Left

Fig. 3. Right





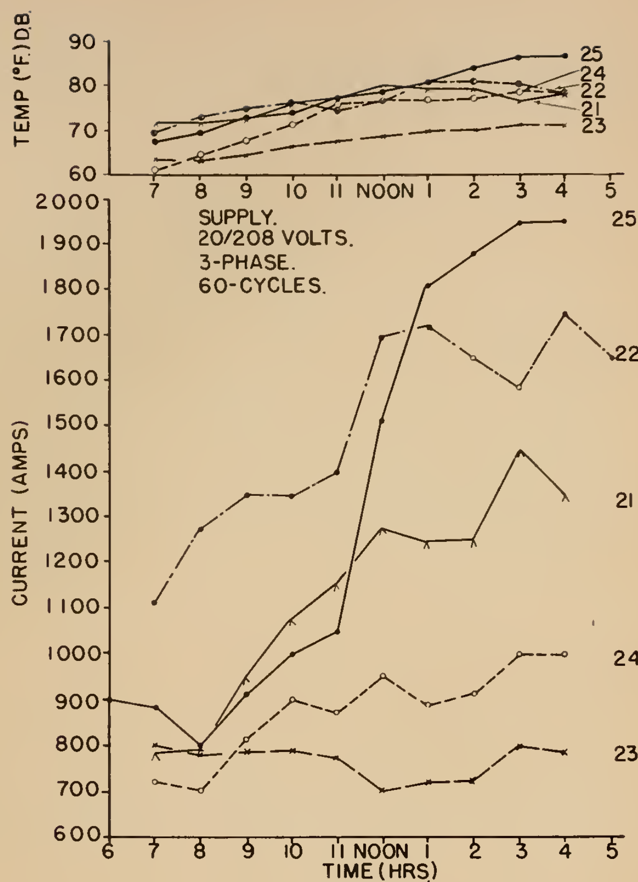


Fig. 4. Left

Fig. 5. Right

Actual tonnages per 1,000 sq. ft. net area for a number of fully air conditioned buildings are also to be found in Fig. 1. It will be seen that these figures are close to that of 3.44 tons evolved earlier, which figure may therefore be found useful for a quick estimation of a load.

It requires power to obtain refrigerating effect and power to distribute this effect to the occupied spaces. In comfort conditioning, one ton of refrigeration is obtained by the expenditure of one horse power, more or less; the figure varies usually between 0.89 and 1.1 h.p. per ton.

In close association with the refrigerating compressor are the condenser water pumps and the cooling tower. It appears that no useful figure can be obtained to relate the motor horsepower required for this associated equipment to that of the refrigeration compressor. The variation in this ratio is dependent upon both the selection of the equipment and the relative positions of the various machines within the building.

In the larger installations it is usual to use the refrigerating machine as a means of chilling water. The chilled water may be pumped to finned tube cooling coils installed in the air conditioning units, to similar coils included in under-window units, and/or to radiant coils in ceilings or walls. Power is also required to distribute air cooled by the medium of the chilled water in the coils installed in the air-conditioning units to the occupied spaces in the building. Here again it is not possible to relate within narrow useable limits the horsepower required for distribution purposes to that for the compressor. For each building a number of conditions are present which render it different from any other building. Among these different conditions are:

(1) Geographical location of the building.
(2) Orientation of the building.
(3) Ratio of superficial area to perimeter.
(4) Ratio of net to gross floor area.
(5) Ratio of window area to outside wall area.
(6) Density of occupation.
(7) Light intensity.
(8) Extent of use of business machines.

For eight installations Fig. 2 shows the connected horsepower required to bring reasonable comfort to the occupants. The total is divided into three parts, the cross-hatched lower portion being the horsepower of the refrigerating compressor, the single hatched portion the equipment intimately associated with the compressor and the unshaded portion the distribution equipment.

Facilities, such as spacious lounges, kitchen and cafeteria to be found in the two buildings (A) and (B), are to be found together in building (D). The total of (A) and (B) are brought together in (C). A conditioned area within a non-conditioned building gives different characteristics to those to be found in a fully conditioned structure; (F) is such a case and is shown for purposes of comparison. (A) employs medium pressure under-window units with a conventional interior zone in which air is admitted to the occupied space through a perforated metal pan ceiling from a supply plenum above it. (B) embraces a number of conventional systems.

Both (D) and (E) employ radiant heating and cooling together with conditioned air distribution. In proportion, (D) employs the radiant method to a greater extent than (E). The installations in G, H, and I are all of the high pressure under-window type, with conventional interior zones. Superimposed on Fig. 2 is a percentage line which indicates the refrigeration compressor as a percentage of the total connected horsepower. Whilst this percentage varies widely, it may be seen that the horsepower of the compressor is only about 60% on the average of the total horsepower required.

Figure 3 shows the connected horsepower required for the air-conditioning plant of the same eight buildings re-

(Continued on page 82)

Buildings for Chemical Plants

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THE SELECTION of suitable types of construction for the buildings needed to house chemical plants presents many interesting problems. The desired objective is, of course, the lowest long term cost. To achieve this, it is necessary to consider factors such as first cost, maintenance cost (which is particularly important if the process is corrosive), fire resistance, heating cost as influenced by degree of insulation, necessary interior finish to minimize dust accumulations or to permit hosing, weather resistance and appearance. The subject is of considerable importance to expanding chemical manufacturers such as Du Pont of Canada, whose investment in plant buildings, exclusive of building services is over $17,000,000.

This paper covers a number of the more important factors by describing, with costs, several types of construction used by this company to meet the various conditions imposed by their processes. The characteristics and limitations of these constructions will be discussed and some of the forward thinking in this field will be reviewed.

Housing Corrosive Processes

The first type of problem involves the provision of low cost non-flammable housings for wet processes of a corrosive nature. Such processes are frequently designed for a minimum room temperature of about 40°F. so that water used in the process and for floor washing will not freeze, no matter how low the ambient temperature may be. A specific example would be the adipic acid refining section of the nylon intermediates plant at Maitland, Ontario. This process involves the handling of acids, the fumes of which are highly corrosive.

Fig. 1. Photo of Kingston Bldg. 5 completed.

As shown in Fig. 3, the ground floor construction which was selected comprised acid proof brick on a concrete slab of earth. Some might expect sufficient heaving of the floor slab due to frost action to crack the brittle joint material used with the acid proof bricks. No noticeable movement has been experienced however during the four years this building has been in operation, due to the careful attention that was paid to the drainage of the sub floor area. This was accomplished by the provision of about two feet of gravel fill under the slab and the installation of perimeter weeping tile drains.

The determination of the allowance to be made in the structural design for future alterations and expansions to such a building is always a problem. While the project engineer has some ideas on the direction of future expansion, technological advances may impose structural loads never imagined during the original design. The policy followed is to steer a course between the Scylla of tight design, permitting no changes without structural alterations and the Charybdis of wasteful overdesign.

The walls selected are of ribbed asbestos-cement board, bolted to steel girts. Because of the specified room temperature of only 40°F., an economic evaluation showed that thermal insulation for the walls and roof could not be justified. The experience with this wall construction has been quite satisfactory. The asbestos-cement board, while brittle, has not suffered excessive mechanical damage, and it has quite good corrosion resistance. A minor drawback, however, has been the need of frequent maintenance painting of the steel girts.

The suspended floors are of reinforced concrete protected with acid proof brick where dictated by process requirements. The roof deck is also of reinforced concrete, because it is, in some measure, an operating and maintenance floor for the equipment located on the roof. No roof covering is used over the concrete deck.

The cost of this building was $1.00 per cubic foot. This figure, in common with all other units quoted covers the direct cost of the structure, factored to an E.N.R. construction cost index of 300. The figure does not include "indirect" charges such as engineering, contractor's profit, and payroll insurance, and it does not include building services, such as lighting, heating or plumbing. While the cost of this building may seem high, it should be noted that its primary function is to support much heavy equipment and piping and that its role of weather protection is of secondary importance.

Fig. 2 shows the finished appearance of this building.

Fig. 2. Photo of completed Bldg. 216.

Dry Storage Construction

The next problem is of importance to all segments of industry. This is the provision of very cheap, dry, unheated storage space where no corrosion is expected.

This particular problem was solved recently at the nylon yarn plant in Kingston by the selection of a prefabricated building having metal wall and roof covering which was erected on a floating slab foundation. Because of the impervious nature of the clay soil on which it was constructed, particular attention was paid to drainage of the sub floor area. As with the last example, a two foot layer of gravel fill was provided under the floor slab together with perimeter weeping tiles.

Fig. 1 is an interior view of the completed building. This structure

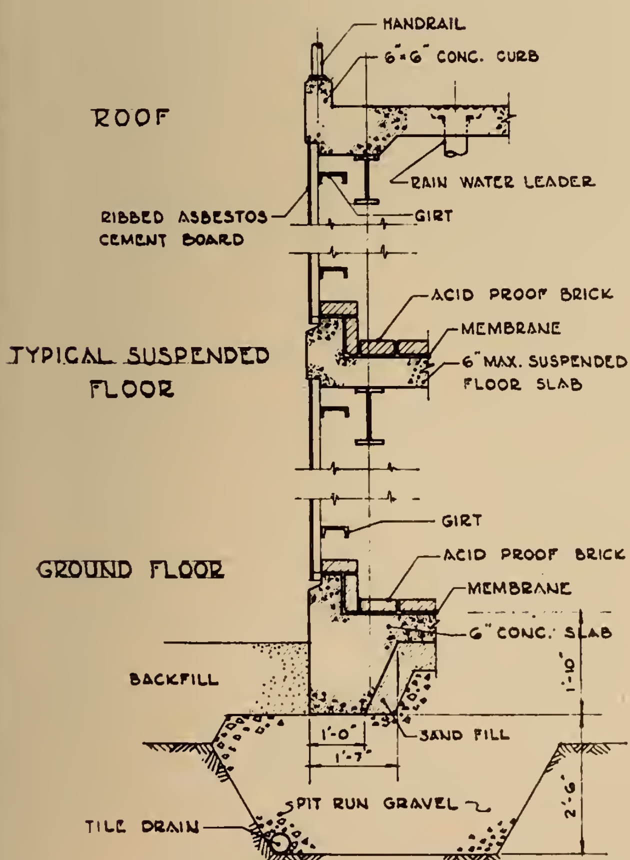


Fig. 3. Sketch of N.I. Construction (Bldg. 216) showing corrosive net process heated to 40°F.

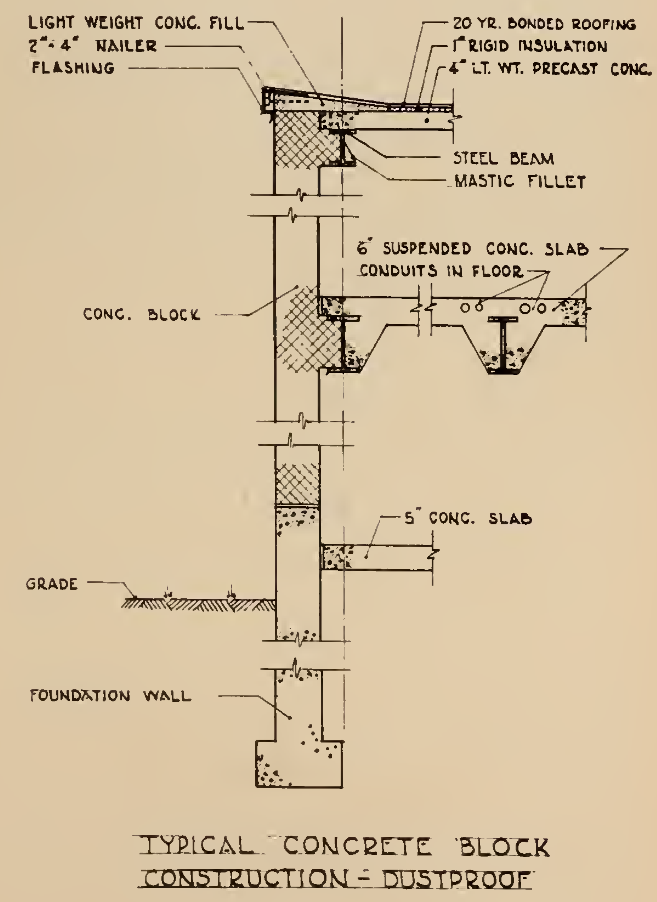


Fig. 4. Sketch of Dope House Construction

which had a floor area of 5600 sq. ft., cost 26c per cubic foot. In comparing this figure with others quoted, it should be recognized that this prefabricated building was engineered and erected by the supplier on a lump sum contract and the owner's indirect field expense and engineering charges were insignificant. This puts this particular unit cost on a considerably different footing from the other unit costs whose basis was described earlier.

Dustproof Construction

The selection of a suitable type of construction for the dope house at the commercial explosives plant at North Bay presented some interesting problems. The dry ingredients for commercial explosives are known as dopes and a typical dynamite may contain six or eight different dope ingredients which are needed to give the desired combination of properties. These dopes, comprising such materials as pulps and meals, are weigh batched in the dope house.

For this operation it was necessary to provide a noncombustible low cost structure with a dustproof interior finish to aid in housekeeping. Because some of the dope ingredients are moderately corrosive, a fair degree of corrosion resistance was desired. Since the building was to be heated to 40°F. only, very little thermal building insulation could be economically justified.

The construction selected, as shown in Fig. 4, included steel frame and concrete block walls. In areas requiring protection of the concrete floors against corrosion from ammonium nitrate, asphalt bridge planking was laid on an impregnated glass fabric membrane. This material which consists of a mixture of asphalt, fibre and mineral filler, is available in various thicknesses and sizes.

To prevent dust accumulations everything possible was done to eliminate horizontal ledges within the dusty part of the building. For example, beam flanges were covered with a mastic fillet or the beams were encased in concrete. Much of the electrical conduit was cast in the concrete floors. The ventilating ductwork was even carried on the outside of the building, in order to eliminate it as a potential location for dust accumulations.

The finished building cost 65c per cubic foot. This fairly high cost resulted partly from the special process requirements of corrosion resistance and dustproofing and partly from the rather heavy and extensive equipment supports that were necessary.

Dry Manufacturing

Also required, at the explosives plant, was a building of some 15,600 sq. ft. to accommodate equipment for the manufacture of shells and boxes. This is a dry operation with a room temperature of 70°F. The lowest cost construction was desired. As shown in Fig. 5, the construction selected comprised a steel frame with a flat roof and insulated wood stud walls covered with aluminum siding and lined with ⅜" plywood. The floor is again of floating slab construction. Because of the paper and wood materials used in this process, it was considered desirable to sprinkler this building and this, in turn, permitted the use of low cost flammable con-

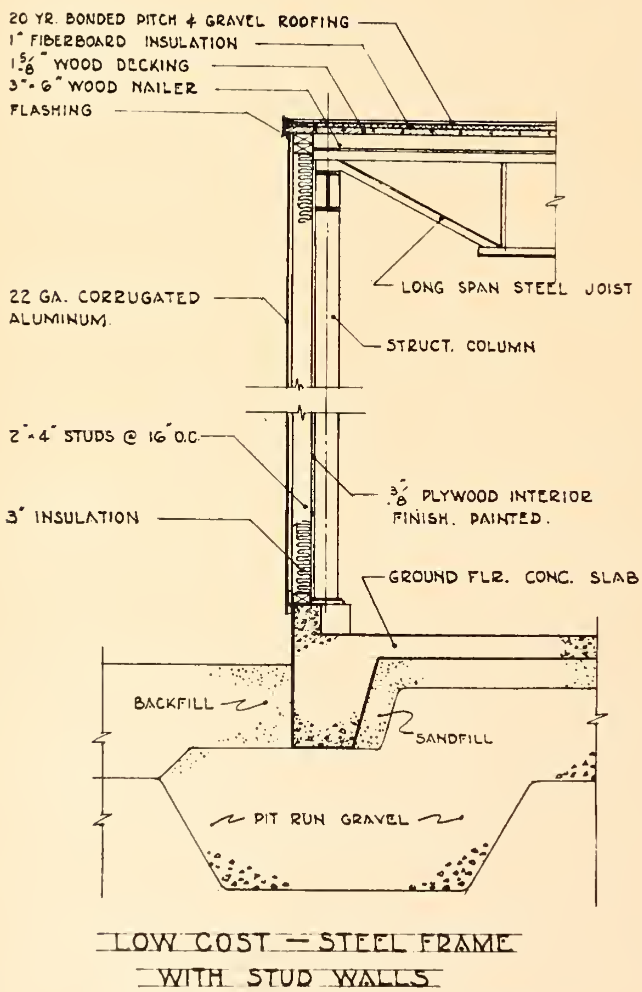


Fig. 5. Sketch of Shell and Box Factory.

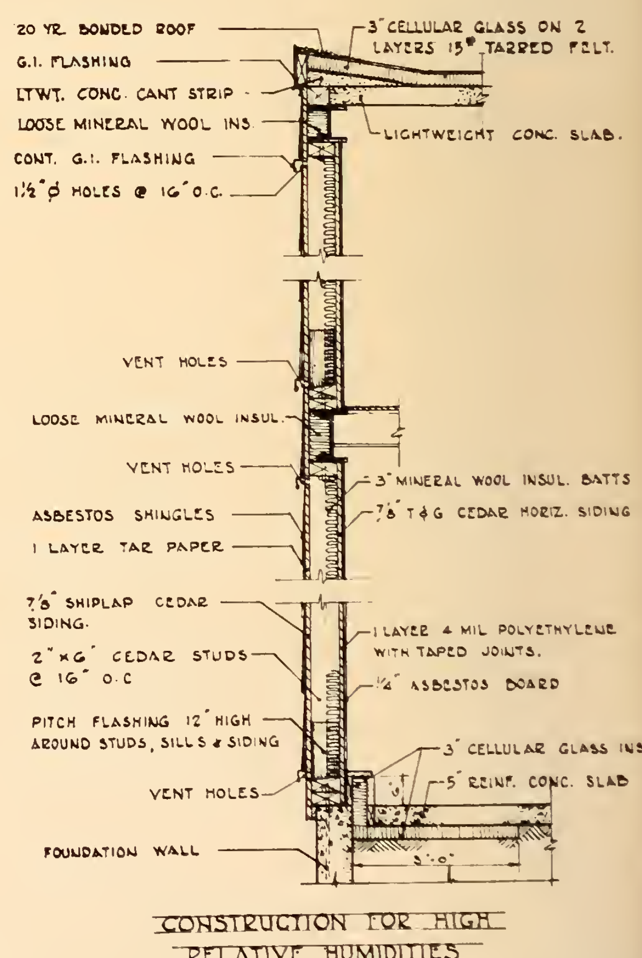


Fig. 6. Sketch of Kingston Wall.

struction materials which might not otherwise have been selected. The cost of this structure at 28c per cubic foot appears to be quite satisfactory when it is remembered that walls and roof are insulated.

Humidified Areas

At the nylon yarn plant in Kingston, many of the operations are carried out in areas maintained at a relative humidity of around 70%. Since the operations are clean and dry and involve no corrosive materials, the main problem results from the high relative humidity. The plant layout anticipates expansion of the humidified areas so most of the outside walls of these areas are of temporary construction. In the early days, before the importance of good vapour sealing was appreciated, extensive rotting occurred in the wood studs and sheathing used in these temporary walls. The solution to this problem, as shown in Fig. 6 involved a three pronged attack. First, a vapour seal of polyethylene film was provided on the room side of the wall, in order to minimize the flow of vapour into the wall. Second, vent holes were bored at the top and bottom of every stud space in order to dissipate, by gravity circulation, any water vapour that might penetrate the wall. Third, cedar studs and sheathing were used and a mopping of hot pitch was specified at the bottom of each stud space, in order to minimize rotting should condensation occur under highly unusual conditions. The wall is well insulated to keep the inner surface above the room dew point of approximately 60°F. in order to prevent condensation at this point.

The roof construction for these humidified areas also presents a problem. Since a built-up roof is by its nature a very good vapour seal, any water vapour that penetrates the roof insulation will be trapped and will eventually condense. The original roof construction used as a vapour seal two plies of roofing felt well mopped with hot pitch. The insulation was of cork, which was covered with a 20 year bonded roof. After a few years' operation, condensation began to appear on the underside of the roof deck in cold weather indicating that the roof insulation was losing its effectiveness. On investigation, it was found that the cork over much of the area was completely soaked with water which had passed upwards through the relatively permeable vapour seal that had been provided.

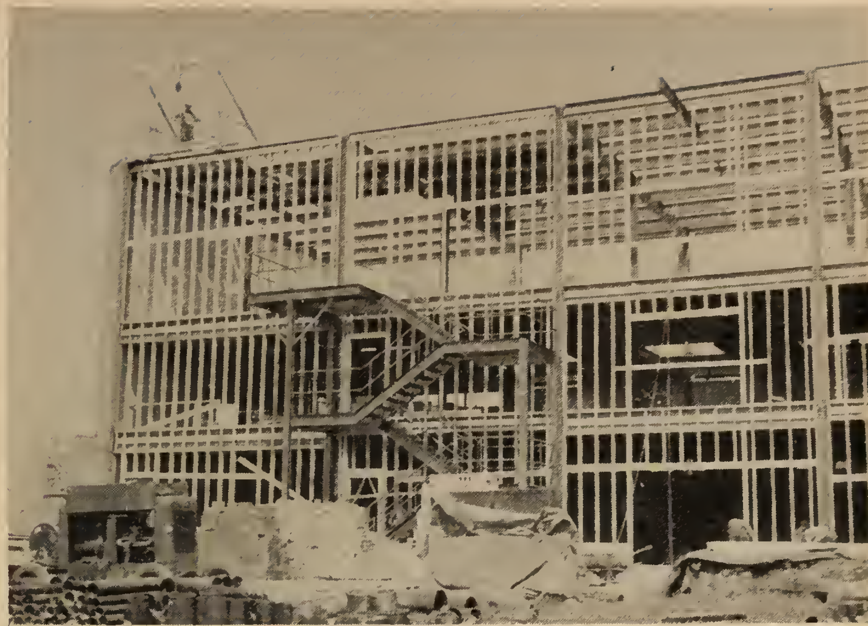


Fig. 7. Photo of Kingston under construction.

The solution to this problem, as shown in Fig. 6, was to use an impervious insulating material consisting of cellular glass. This construction has been completely adequate for the period of more than ten years that it has been in use at the nylon plant.

Fig. 7 shows a typical temporary wall under construction for a humidified area at the Kingston works. Because of the need of gravity circulation to remove moist air from the stud space, no headers are used between vent holes.

What of the Future?

These examples highlight some of the factors which have been considered in the selection of suitable housings for chemical plants. Experience has shown that these constructions are effective, but what of the future?

Sandwich wall constructions, such as mineral wool between aluminum, are becoming of more interest as their cost is reduced through improved installation techniques. Prefabricated sandwich panels should be of particular value for semi-permanent walls, because of their expected low cost, high salvage value and speed of erection.

Another subject for further investigation is the critical evaluation of prefabricated buildings for various applications. While several good makes are available, they are not necessarily cheaper than low cost custom built buildings. More information must be developed on the best applications for each of these types.

Still another area, is the use of advanced engineering and construction techniques. Plastic design, of which the first example on the North American continent is in a commercial building located in Kingston, Ontario, will lead to more economical structures. There is a place, in the chemical industry, for structures of precast and prestressed concrete. These structures, in addition to being economical, also provide excellent corrosion resistance in some environments which are highly corrosive to structural steel. On the construction side, experience with cylindrical paper tube forms for column piers has been excellent. It is thought that foundation costs can, in some instances, be further reduced by using these forms with auger drilled holes. Other techniques that should lead to cost reductions include the palletizing of construction materials, the use of stud welding for fastenings and the use of road pavers for construction of large floor slabs.

Because of the numerous interrelated factors, the selection of the best construction under any set of circumstances must be based on experienced judgement; because of rapid advances in design and construction techniques, what is best today may be completely outmoded tomorrow.

PHOTOGRAMMETRY IN HIGHWAYS AND RAILWAYS ENGINEERING

This paper discusses the application of photogrammetric engineering methods and electronic computers to highway and railway location problems. It describes the steps usually followed in location work and illustrates each phase of the work with practical examples. The techniques used in air photo analysis, ground and photogrammetric surveys, and methods of computing earth work quantities for estimates and pay purposes are described.

J. M. Zarzycki, M.E.I.C. *Chief Engineer, Engineering and Photogrammetry Division, Canadian Aero Service Limited*

TODAY'S RAPID development of vast areas of Canada represents a continuous challenge to the engineering profession. As we plan new highways and railways, the engineer has the difficult task of locating the best route and producing the best possible design in a very limited period of time. Not so long ago, the "classical" method of location was to travel the area on foot and examine the terrain from high points or to fly over it in an airplane and select a preliminary route. Only limited information could be obtained, and the route selection was done without detailed knowledge of topography, geology, soils and drainage. Alternative routes, more desirable than the one staked on the ground, were often overlooked.

The problem of route selection was always a challenge to the photogrammetric engineer. To meet this challenge the photogrammetrists have developed, during the last few years, precision aerial cameras, plotting instruments, and new advanced interpretation and compilation methods. Modern photogrammetric instruments have been combined with electronic computers to provide more speed, economy and precision in computation of excavation quantities. Today photogrammetric methods are being more and more widely used by highway and railway engineers.

Photogrammetry, a branch of civil engineering, is the science of obtaining various survey information by means of special types of photographs and interpretation procedures. It develops data heretofore collected laboriously on the ground. Its aim is to reconstruct precisely the measurements of two or three dimensional objects from photographs, and to obtain geological, soil, forestry and all geographical information of the photographed area.

Photogrammetric surveys for highway and railway location and design proceed in five steps:

(1) Reconnaissance survey of the entire area between terminal points to determine all feasible routes.

(2) Reconnaissance survey of these routes, in more detail, to determine the best route.

(3) Detailed reconnaissance of the selected route to produce a "paper location" of the semi-final line.

(4) Detailed survey of the semi-final route for the preparation of accurate cross sections and large scale topographic plans of selected areas. for major culverts and bridge sites. overpasses and clover leafs.

(5) Detailed survey of the route after construction for the purpose of determination of pay quantities.

How these surveys are carried out is described below.

(1) Reconnaissance Survey of the Area

After the traffic study is completed and the terminal points of the railway or highway are determined, the work of the photogrammetric engineer begins. Through a stereoscopic study of small scale aerial photographs (scale 1 in. = 1 mile, or 1 in. = 3333 ft.) the photo interpretation specialist provides the location engineer with reconnaissance information concerning geology, soil, drainage, land use and topography. From careful study of all pertinent factors over a broad area, several feasible routes are selected. The results of this study are presented in the form of a report in terms familiar to the location engineer. These results are keyed to a map or photo index and contain a general interpretation of the engineering significance of the data.

Since Canada is covered by aerial photographs made for the Federal

Fig. 1. An example of a photo analysis.

Fig. 2. The outlined strip on this reconnaissance map has been chosen to be re-photographed as the selected route. The new photograph will be used for detailed photo analysis and the preparation of accurate topographic plans *(32.5% reduction from original drawing).*

or Provincial Governments, the preliminary reconnaissance survey can be undertaken at any time of the year. The time necessary and costs involved are only a small fraction of time and costs for a reconnaissance survey on the ground. Furthermore, through the examination of a broad area, it is possible to study all alternative routes.

(2) Reconnaissance of the Alternative Routes

After alternative routes are selected, each one is studied in detail.

All the pertinent information needed by the location engineer for his study and choice of the best route can be provided by photogrammetry. In areas covered by National Topographical Series maps at a scale of 1 in. = 1 mile with 25 ft. or 50 ft. contours, it will be necessary for the photogrammetric engineer at this stage to conduct only a more detailed photo analysis of each route. A general study of grades and the extent of excavation and fill required can be conducted by the location engineer with the help of existing Federal Government topographic maps. This detailed study of the aerial photographs will provide information concerning drainage, general requirements for bridges and major culverts, the amount of rock excavation and location of gravel and aggregate materials needed for highway construction work. The aerial photographs will also provide valuable information about land use and property boundaries.

When the available aerial photographs are out-dated or of poor quality, it is advisable to fly new photographic coverage along each alternative route. This is particularly recommended when reconnaissance type maps must be prepared for areas lacking Government topographic maps. Photographs for this purpose are usually taken with a 6-in. focal length lens at altitudes of 30,000 or 20,000 feet above the ground giving a scale of 1 in. = 5000 ft. or 1 in. = 3333 ft. respectively. To obtain a stereoscopic coverage, the pictures are taken with 60% forward overlap and approximately 30% side overlap between the flight lines. The terrain can be viewed in three dimensions by using a simple stereoscope. These aerial photographs, which provide an up-to-date picture of the ground, are very useful in conducting more detailed photo analysis of each route. Furthermore, as these flight lines are planned to follow each alternative route, the compilation of 25 ft. contour reconnaissance maps will proceed more easily, faster, and less expensively than by using existing photographs. Reconnaissance type topographic maps compiled from aerial photographs show contours, drainage,

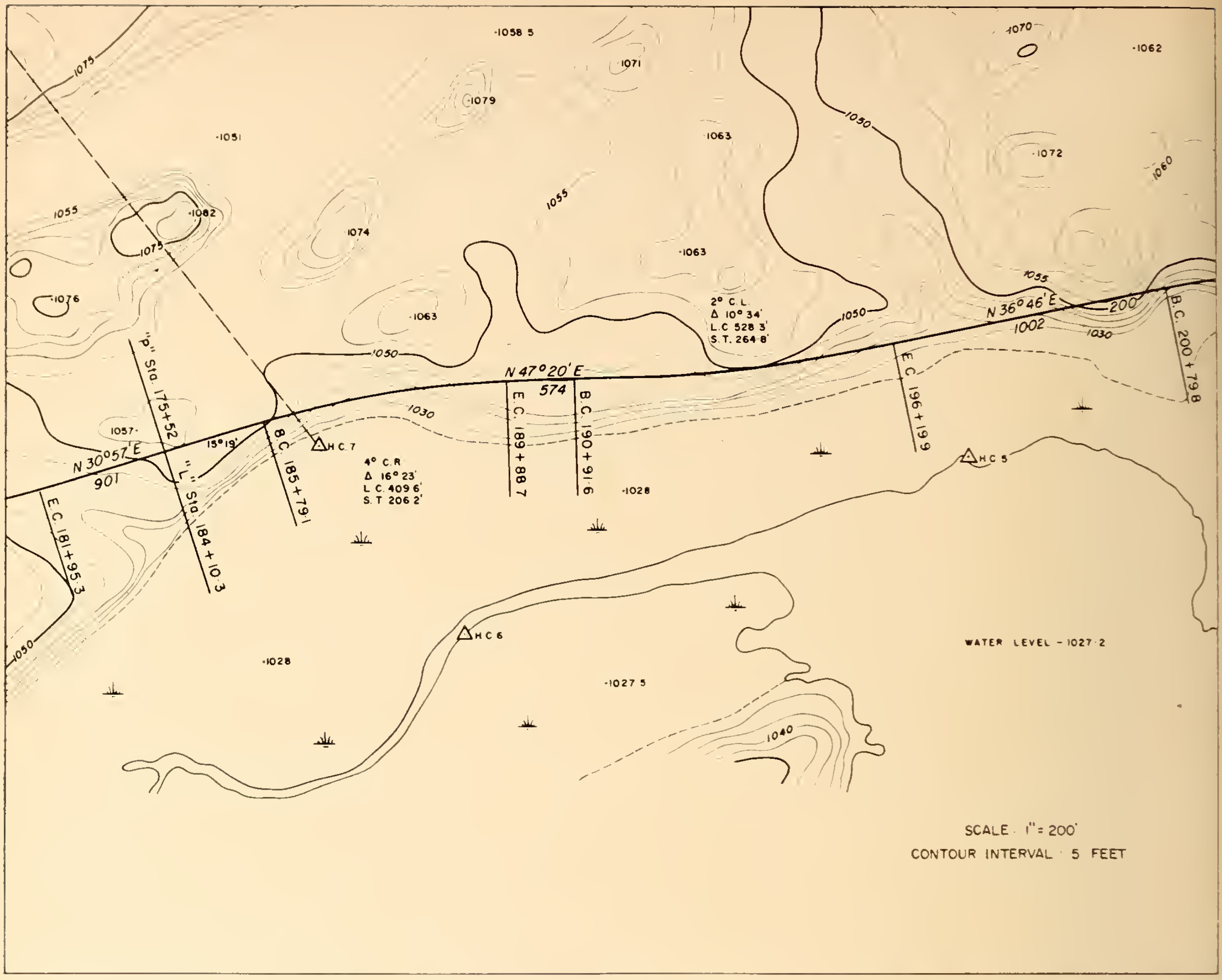


Fig. 3. The semi-final line is projected on a detailed plan as shown. This plan is used by ground survey crews in staking the centre line of the railway. *(32.5% reduction from original drawing).*

Fig. 4 The Kelsh stereo-plotter allows the operator to view an exact optical model of the photographic terrain. Contour lines and planimetric features can be traced off directly.

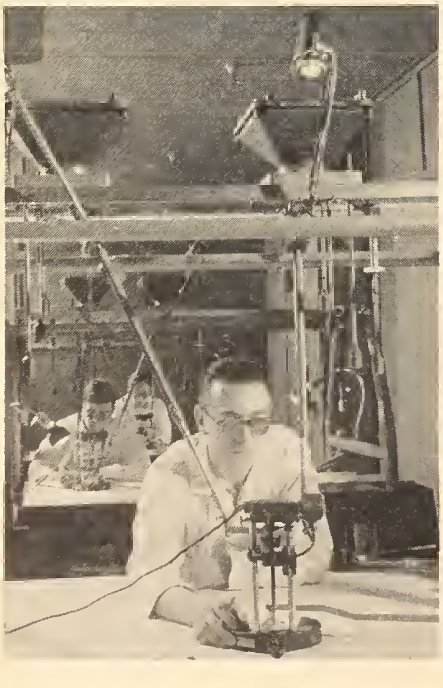


Fig. 5. The completed photo contour map. This is not a mosaic with superimposed contour lines but is a true orthographic projection.

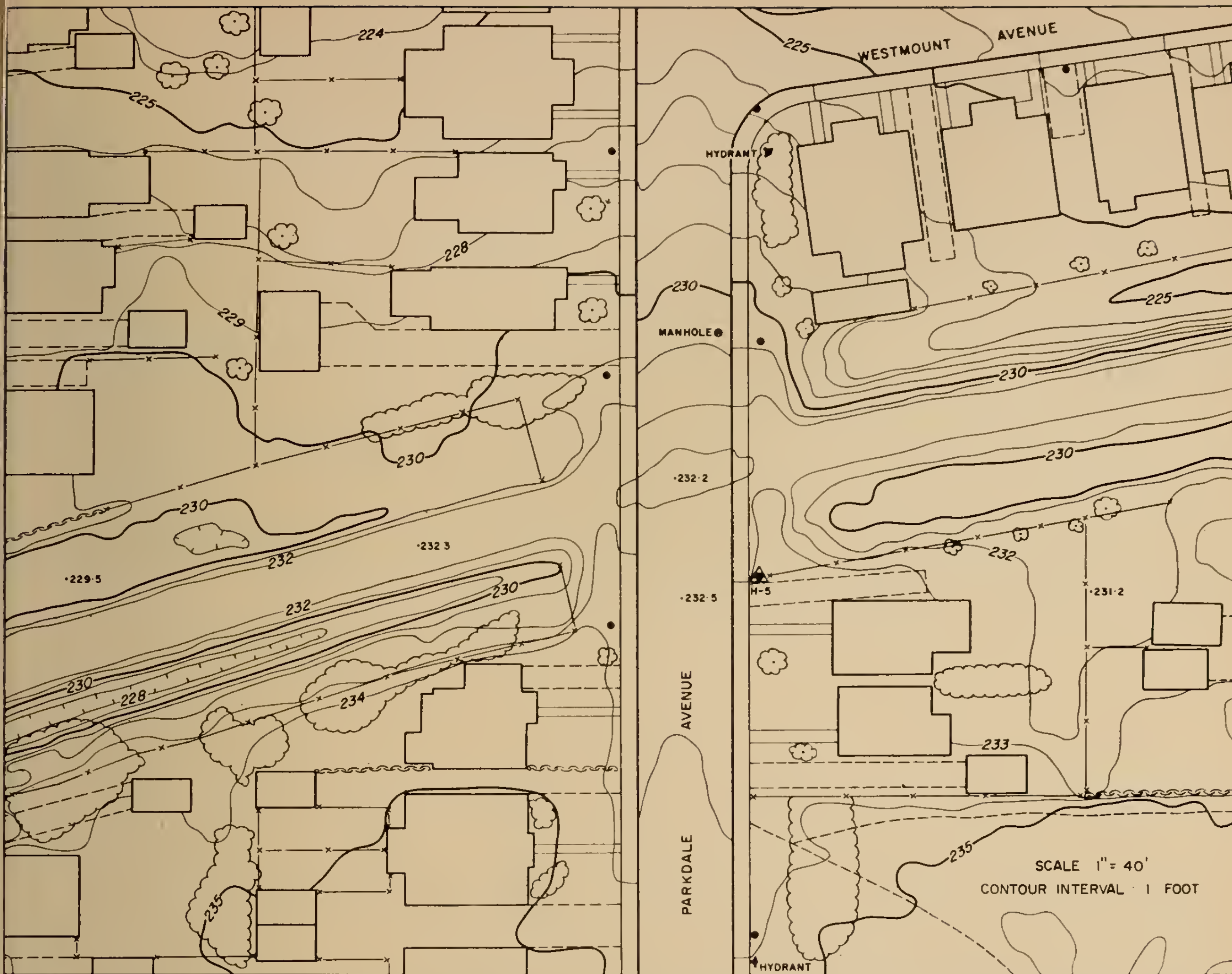


Fig. 6A. Large scale engineering plan of a portion of the proposed Queensway in Ottawa. ***(32.5% reduction from original drawing).***

roads, railways, county and township boundaries, major buildings, cross country power lines, and other important planimetric details. Contours compiled photogrammetrically express the land forms with far more detail than would be possible to obtain by ground survey methods. The most useful scale for the reconnaissance type maps is 1 in. = 1 mile or 1 in. = 2640 ft., and the contour interval 25 ft.

In most cases it is advantageous to prepare an uncontrolled mosaic from the high level photographs of each route. The scale of the mosaic should be approximately the same as the scale of the reconnaissance type topographic map. An uncontrolled mosaic is obtained by matching aerial photographs together to an approximate scale. The photographs are not corrected for the tip and tilt of the aerial camera at the moment of exposure. Therefore, an uncontrolled mosaic will show horizontal displacements of planimetric details due to tilt of the aerial camera and also due to the relief of the ground. Although accurate measurements cannot be made from mosaics, they serve a useful purpose. For example, the results of the air photo analysis and other pertinent location data can be conveniently shown on the mosaic. Such a presentation of engineering facts is very useful in discussions with laymen unfamiliar with engineering drawings.

Not only do the aerial photographs provide a vast amount of information over a broad area, but these studies can be carried out in the office without involving ground surveys, and therefore can be kept confidential. This is important to the location engineer and the administrator. Thus it is possible to eliminate in the planning stage property owners' concern and speculative real estate transactions. Consequently, the right-of-way can be secured for a more reasonable amount.

(3) Detailed Reconnaissance or Preliminary Survey of the Selected Route

The steps outlined in the previous paragraphs have brought the location engineer to the point where he can select one strip and be confident that he has selected the most practical and economical route. All this preliminary reconnaissance was completed substantially without setting foot on the ground.

In the location of the semi-final centre line of the road or the "P" line within the selected strip, photogrammetric methods especially developed for this purpose are of great assistance. The first step is to secure large scale aerial photographs of the entire route. These photographs shall be suitable for compilation of topographic maps portraying 5 ft. contour intervals at a scale of 1 in. = 200 ft. In relatively flat areas it is recommended that 2 ft. contour intervals be used. The width of the mapped strip is usually one mile, but it varies according to the topography. The scale of the aerial photography taken for compilation of 5 ft. contours is usually 1 in. = 1000 ft. The mapping plane's altitude, and consequently the

Fig. 6B. Aerial photograph taken from an altitude of 1800 ft. The area shown in Fig. 6A is outlined on the photograph.

Fig. 7. A field crew on location in Northern Quebec using the Telluro-meter, electronic instrument for distant measurement.

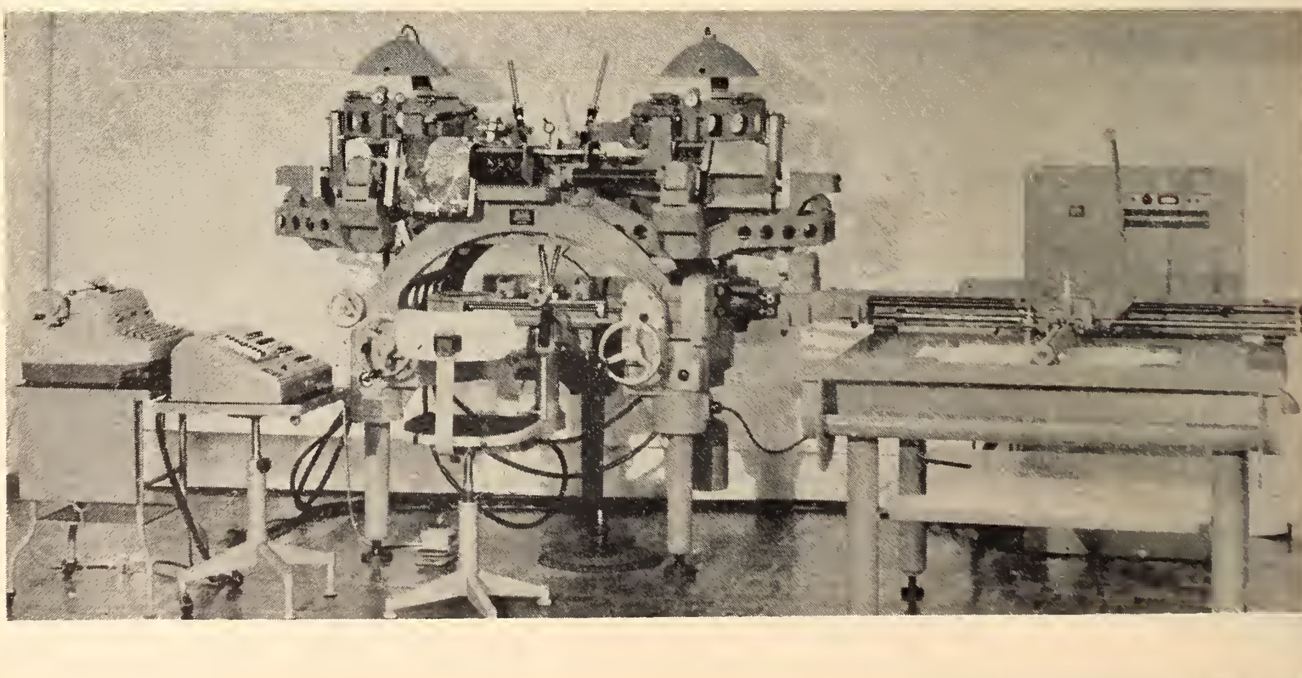
scale of the aerial photography for a given vertical accuracy, depends largely upon the type and quality of the lens in the aerial camera and upon the type and accuracy of the stereo-plotting instruments to be used for compilation. Therefore, the final recommendation as to the scale of the aerial photography and compilation methods should be made by the photogrammetric engineer responsible for the project.

To provide the location engineer with necessary information for the location work, the photogrammetrist will conduct a detailed photo analysis, establish vertical and horizontal ground control, and compile accurate topographic plans.

The detailed photo analysis will call the attention of the location engineer to specific or unusual situations and will provide information concerning rock and soil types, approximate depth of bedrock, location of possible sources of gravel and aggregate materials, location of quarry faces and outcrops, direction of dip of bedding plains, and the location of areas subject to slide. The photo analysis data are field checked before they are submitted to the location engineer. These field checks are of great importance and should be an integral part of the detailed photo analysis. The purpose of the field check is to sample necessary keys and to prove the validity of the information obtained from aerial photographs. The land use data are also obtained from aerial photographs by functional classification of the land along the proposed right-of-way.

The results of the photo analysis are presented in the form of an an-

Fig 8. A Wild A-8 Autograph with attached electronic coordinate printer. The tape immediately below the picture contains data on the coordinates of cross-sections obtained with the A-8 instrument. The second tape represents the program for electronic earthwork calculation.



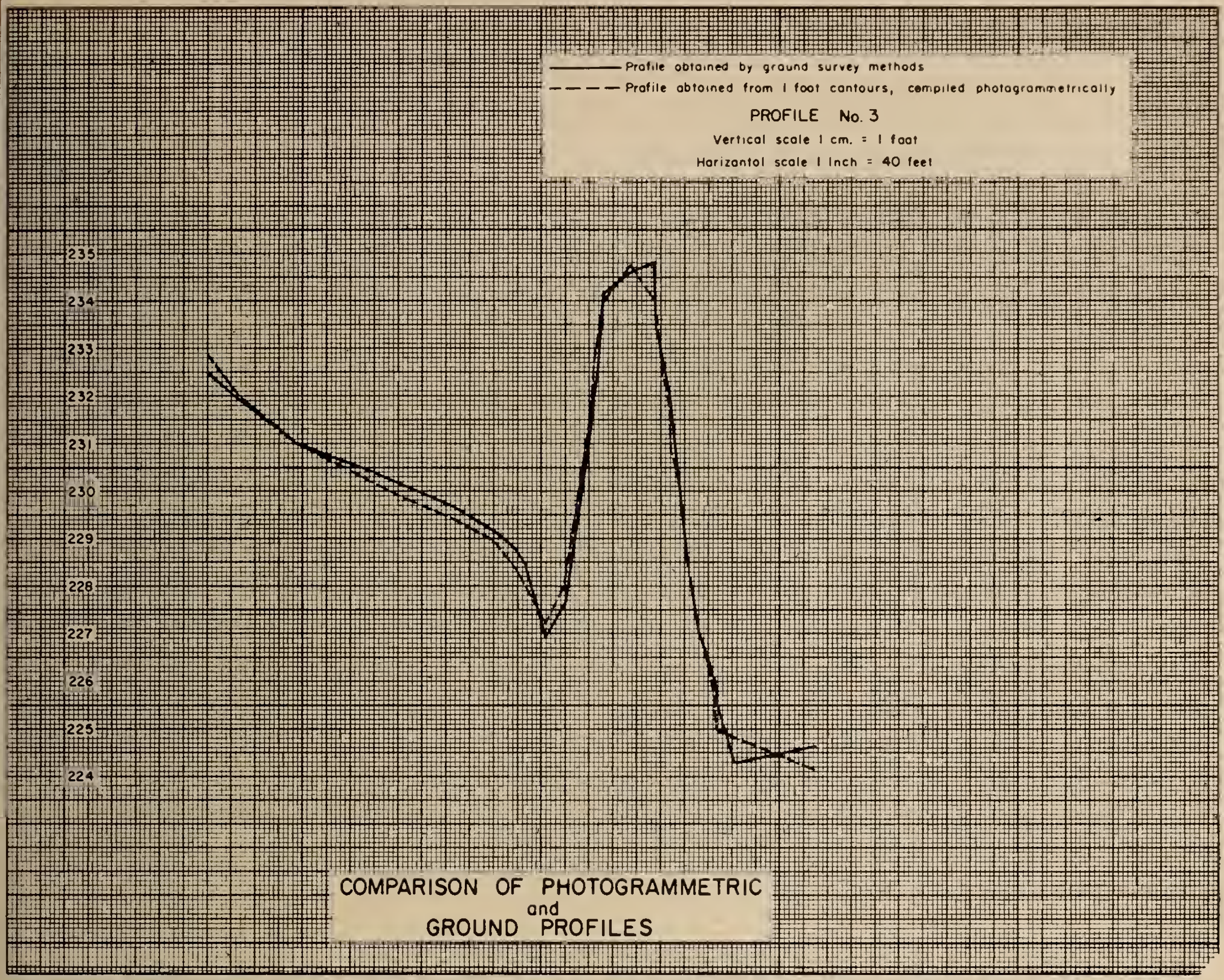


Fig. 9 (A). Comparative study of profiles surveyed by standard ground methods and by photogrammetry. The maximum deviation was found to be 0.5 ft. and the average deviation 0.2 ft. *(32.5% reduction from original drawing).*

notated mosaic with overlays showing soil, geology, borrow materials and land use classifications. This graphical presentation is accompanied by a written report discussing the engineering significance of the data. Based on the information provided by photo interpretation, the design engineer can lay out a more effective boring program and thus reduce substantially the time and cost of soils investigation.

The topographic plans required for location of the preliminary or semifinal line can be compiled most economically by photogrammetric methods. It is necessary to establish vertical and horizontal control on the ground for the purpose of "levelling" and "scaling" of the aerial photographs for this compilation. Careful planning of the ground survey is very important since it will not only influence the accuracy of the topographic plans but also will be of great assistance in staking of the centre line on the ground. The approach followed on large railway projects in Northern Manitoba and Quebec is to run accurate traverses and levels close to the proposed centre line as determined from preliminary photo interpretation and reconnaissance maps. Bench marks and traverse stations should be permanently marked approximately every mile and described. In addition, position and/or elevation of points readily identifiable on the aerial photographs should be established so that accurate topographic plans can be compiled.

In connection with ground control survey, the new electronic distance measuring device, the Tellurometer, is very useful. This instrument, which was developed in South Africa, measures distances from 1,000 ft. to 30,000 ft. with an accuracy of 2 inches. The only power supply required is a 6-volt automobile battery. The equipment consists of a "master" and a "slave" station, each weighing approximately 30 lb.

After the ground control is established, the topographic plans are compiled, using stereo-plotting instruments such as the Kelsh plotter or Wild A-8. Planimetric details such as roads, railways, streets, buildings, streams, rivers, water bodies, power lines, permanently marked traverse stations and other pertinent details are plotted from aerial photographs together with contour lines. The most useful scale and contour interval for the detailed reconnaissance type of plans is 1 in. = 200 ft. with 5 ft. contours. In flat areas 2 ft. contours are recommended. This plan covers a strip between one-half to one and one-half miles wide and thus gives the location engineer detailed information over a large enough area.

The standard accuracy of the topographic plans generally accepted is as follows.

Horizontal Accuracy — 90 per cent of all well-identified features shall be plotted to within 1/20 inch of their correct relative position. In urban or

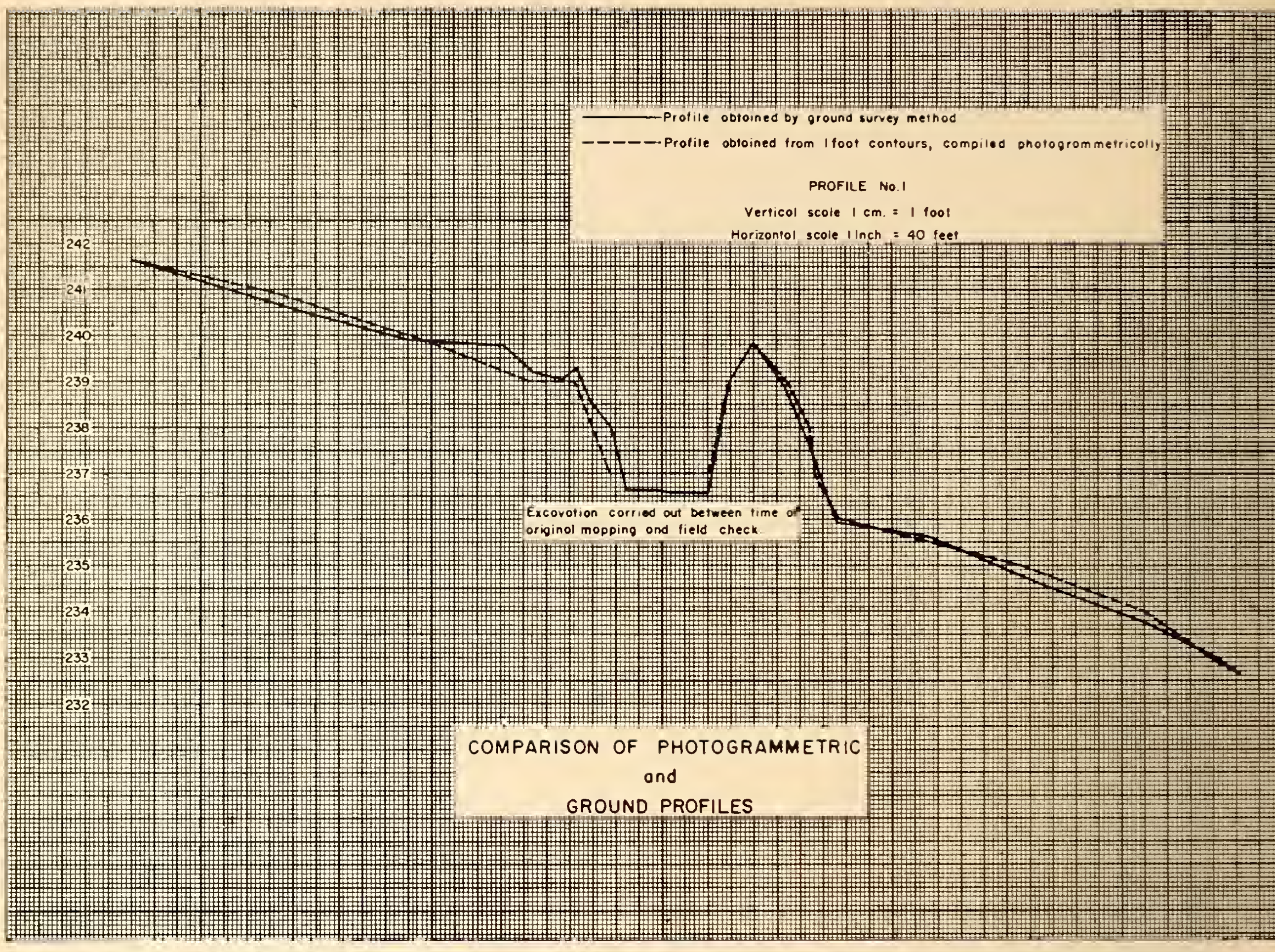


Fig. 9 (B). Comparative study of profiles surveyed by standard ground methods and by photogrammetry. The maximum deviation was found to be 0.5 ft. and the average deviation 0.2 ft. ***(38.3% reduction from original drawing)***

heavily developed suburban areas, the horizontal accuracy required is 1/40 inch. In these cases the plans should be drafted on a stable material, and not on linen. The maximum error should not exceed twice these specified accuracies.

Vertical Accuracy — 90 per cent of all contours shall be accurate to within one-half the contour interval. The maximum error should not exceed one full contour interval. This vertical accuracy can be maintained except for areas covered with heavy trees and heavy undergrowth. In such areas, the aerial photos should be annotated for the engineer to show different zones of vertical accuracy, according to density of tree cover in the area.

The topographic plans, together with the result of the photo analysis, provide the basis on which the design engineer can determine a number of feasible routes for the railway or highway. The engineer can project the centre line on these and determine grades, bearings of the tangents and coordinates of the P.C.'s, P.T.'s and P.I.'s. He can also compute preliminary excavation quantities and classify the excavated materials. Computing machines may also be useful to provide information on cut and fill for each tentative route. Using these data, the centre line can be transferred easily from the plans to the ground. The staking of the semi-final centre line on the ground will proceed more rapidly since it will not involve any extensive basic survey work and will eliminate the necessity of running trial lines. Ground survey conducted previously for the purpose of establishing control for photogrammetric mapping forms the skeleton from which the new centre line is surveyed. Experience shows that the final line of the railway or highway does not vary by more than 100 ft. from the semi-final line determined by using information supplied by photogrammetry. Very often these variations amount to 20 ft. or less.

The photo contour map should be considered also for location work. This new technique is a result of an ingenious combination of photogrammetric principles and was developed by R. W. Towill. The photo contour map shows both contour lines and a photographic image of all planimetric and cultural details of the area. It is not a mosaic with contours superimposed, but a true orthographic projection. In compiling this map each aerial photograph is corrected for tip, tilt, scale, and topographic relief. The correction for the relief is made for each contour interval. The location and design engineer will find this new map of great assistance in solving many problems because of the wealth of information it provides; it gives him continual reference in the field.

(4) Detailed Survey of the Semi-Final Route

After the semi-final or "P" line of the highway or railway has been transferred to the ground from the topographic plans, the possible borrow-pit sites and the right-of-way are photographed at a very large scale. If the route is covered by heavy timber or dense undergrowth the right-of-way should be cleared before the photography is taken. These photographs are used for compilation of detailed topographic plans at 1 in. = 20 ft. or 1 in. = 40 ft. or 1 in. = 50 ft. with 1 ft. contours and also for determination of cross sections and excavation quantities.

The necessary ground control for compilation of the detailed plans can be easily established at the time when the semi-final centre line is staked on the ground. These large-scale plans have been found very useful for detailed design of multi-lane highways, bridges, clover leafs and major culverts. The plans may be prepared for the entire right-of-way or only for selected areas.

In addition to planimetric details usually shown on the 1 in. = 200 ft. or 1 in. = 100 ft. plans, these large-scale plans also show culverts, sanitary and storm sewers, telephone poles, hydrants, curbs, and all structures, roads and railways, and all property lines visible on aerial photographs. Invert elevations for manholes, catch basins, and underground utilities can be added to the plans after a field editing. Plans of this type at a scale of 1 in. = 40 ft. with 1 ft. contours have been recently prepared by photogrammetric methods of the proposed Queensway in Ottawa. These plans are being used by the consulting engineers, for the detailed design, quantity estimates and solving of other problems encountered. To check the accuracy of these plans, profiles have been run on the ground and compared with the profiles obtained from contours plotted photogrammetrically. Figures 9A and B show this comparison, which establishes that the contours are well within the specified accuracy of 6 inches.

The same aerial photographs can be used for the determination of cross-sections of the terrain before construction and computation of slope stake data and accurate earth work quantities. For this purpose the precise stereo plotting instruments are coupled with a punched card or punched tape printer. The computations are performed by high-speed electronic computers. At the suggestion of the author the Wild Company, of Switzerland, has modified the A-8 stereo plotting instrument, adding an electronic printer which punches on a tape or card the XY coordinates and elevation of every point of the stereo model by simply pressing a button. When a profile or cross section must be established photogrammetrically, the stereo operator places the measuring dot on the ground along the cross-section to be taken and presses a button. At this moment the position and elevation of the point is registered on the tape. Every point along each cross-section and profile is measured and registered in this way. To compute slope stake data and the design quantities, this punched tape is fed to an electronic computer together with the design criteria and information covering type of materials along the route. The electronic machine computes the cut and fill quantities classified according to the type of materials, as well as vertical curves and the distance from the centre line and elevation of each slope stake. These data can be directly used for preparation of contract documents and for the detailed staking of the route. A graphical presentation of the cross-sections punched on tape is obtained by employing an Electro Dataplotter. This instrument (Fig. 11) draws the cross-sections at the required scales automatically from the punch tapes or cards. By using photogrammetric methods combined with electronic computers, the earth work quantities and slope staking data can be obtained much more quickly and cheaply than by using ground survey methods.

(5) Detailed Survey of the Route After Construction

This survey consists of the computation of progress and final pay quantities and preparation of plans and profiles of the route after construction.

The determination of pay quantities can be done by photogrammetric methods. After the road or railway is constructed, the entire route and the borrow pits are photographed at a very large scale. From these photo-

Fig. 10. A Kelsh plotter with a digital readout system developed by Canadian Aero Service engineers. The station number, distance from the centre line and the elevation of each point along a cross section are punched automatically on a tape.

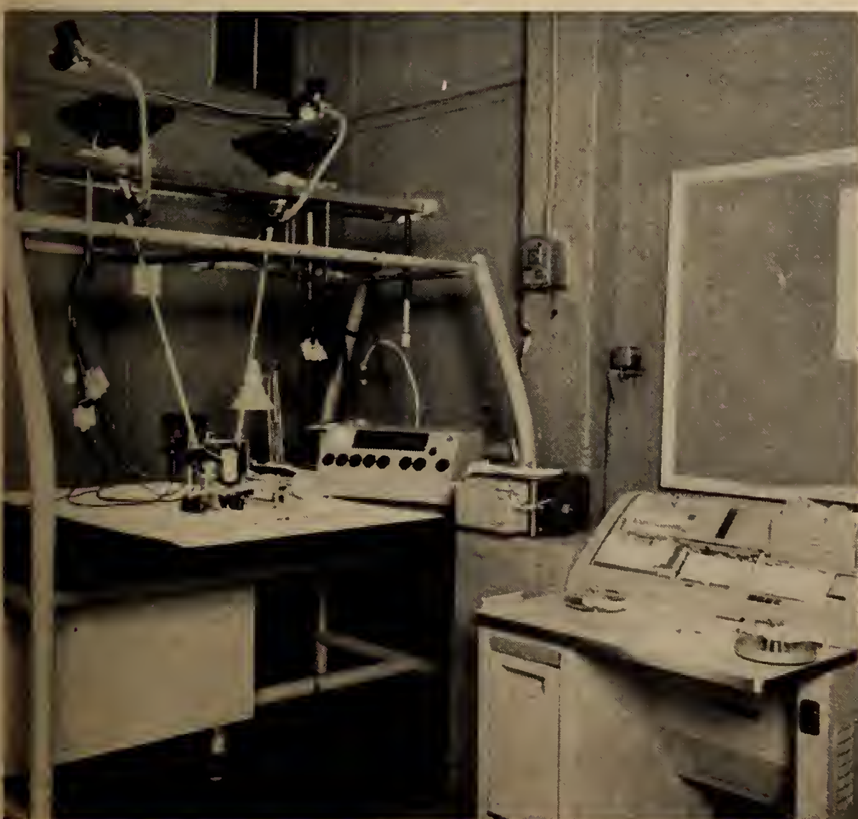
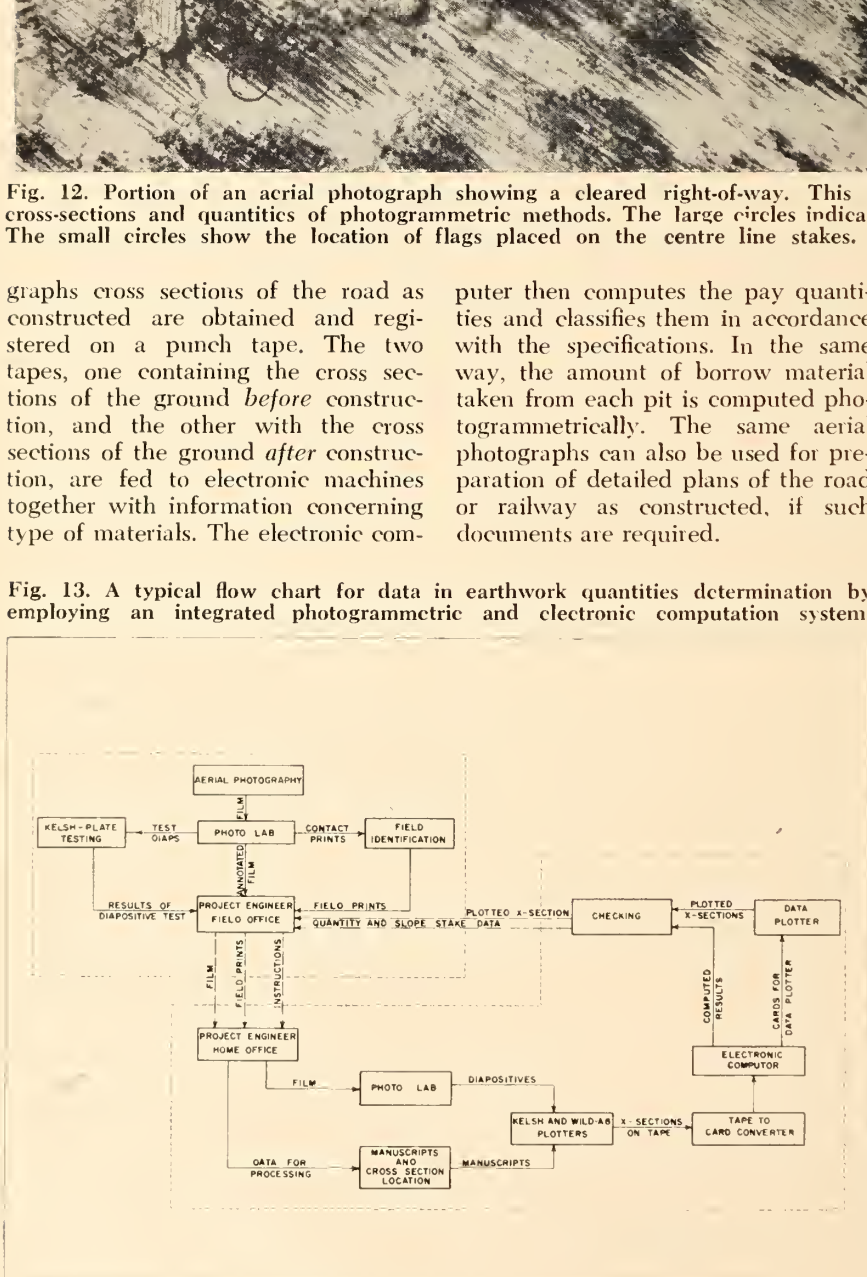


Fig. 11. The Electro Dataplotter for plotting of profiles and cross sections from punched tape or punched cards.

Fig. 12. Portion of an aerial photograph showing a cleared right-of-way. This was taken for the purpose of obtaining cross-sections and quantities of photogrammetric methods. The large circles indicate the location of permanent control points. The small circles show the location of flags placed on the centre line stakes.

graphs cross sections of the road as constructed are obtained and registered on a punch tape. The two tapes, one containing the cross sections of the ground *before* construction, and the other with the cross sections of the ground *after* construction, are fed to electronic machines together with information concerning type of materials. The electronic computer then computes the pay quantities and classifies them in accordance with the specifications. In the same way, the amount of borrow material taken from each pit is computed photogrammetrically. The same aerial photographs can also be used for preparation of detailed plans of the road or railway as constructed, if such documents are required.

Fig. 13. A typical flow chart for data in earthwork quantities determination by employing an integrated photogrammetric and electronic computation system.



The compilation of earth work quantities by photogrammetric methods offers many advantages:

(i) These computations can be done faster and less expensively than by ground survey methods.

(ii) By using photogrammetry a considerable saving of field engineering staff is achieved.

(iii) The cross sections obtained photogrammetrically reflect the shape of the ground more accurately than those surveyed on the ground. This is particularly true in areas of large cuts where the process of surveying cross-sections on the ground is incomplete and proceeds very slowly, which may result in delays in supplying the contractor with necessary information.

(iv) The computations are performed by a third and impartial group.

(v) The possibility of human error is practically eliminated because the cross-section data obtained in a stereo plotting instrument are directly punched on a tape and the computations are performed electronically.

(vi) The aerial photographs provide a rapid, convenient and indisputable record of the ground before and after construction, and many disputes can be settled in the office without the necessity of sending field crews to the area.

(vii) These photographs obtained

(Continued on page 88)

WHAT HAPPENS TO APPLICANTS FOR NATIONAL RESEARCH COUNCIL SCHOLARSHIPS IN SCIENCE AND ENGINEERING

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Division of Administration and Awards, National Research Council, Ottawa.

SINCE 1917 the National Research Council of Canada has maintained a system of scholarships to assist graduate students in science and engineering who have shown promise of research ability. Altogether nearly 3500 awards have been held by a little more than 2000 graduate research students.

During the twenties the number of awards increased moderately from year to year, reaching a total of 592 in 15 years. The program suffered a severe setback during the depression of the thirties and it was not until the Second World War that it regained the level of the predepression years. In 1946, 30 years after its inception, the total number of awards granted had reached 1369.

Immediately after the war the annual number of awards began to increase rapidly. This was due partly to the fact that so many war veterans upon completing their bachelor's degree decided to continue studying for higher degrees. But it should be noted also that Canadians had become more conscious of the important role which science and engineering could play in the expansion of the country. In the eight years which followed the war, the Council awarded more scholarships than it had in the thirty previous years of its existence. In the last three years (1955-57), an average of 220 scholarships have been awarded each year.

The growth of this scholarship program has paralleled the development of facilities for graduate study and research in Canadian universities, and it has played an important role in the training of scientific personnel to meet the academic and industrial needs of the nation together with those of its public service. The annual expenditure for National Research Council scholarships has now passed the half-million mark.

SCHOLARSHIP COMPETITION

At present there are four types of scholarships offered in science and engineering. The bursary is awarded to those who have had no previous research experience and the studentship to those who have had one year or more of experience in research following graduation. Both these scholarships are tenable only in Canadian universities, and cover a working period of 8 months. They may be supplemented by an additional sum if the student works for a full year on his program. The other two types of scholarships are for study and research outside Canada. The special scholarship is given to those who have completed the requirements for a master's degree and desire to study in a field in which it is difficult to get the training in Canada, or to work under a world-famous scientist. The postdoctorate overseas fellowship may be held by those who have completed a doctorate degree and who wish to add to their experience by specialized training abroad. These last two awards are for a tenure of 12 months.

The scholarship competition is held annually in March. In each of the past few years over 500 applications

* Awards and Committee Services, National Research Council, Ottawa, Canada.

have been received. The members of the Honorary Advisory Council for Scientific and Industrial Research, better known by its short title—National Research Council—take direct responsibility for awarding all scholarships. This Council comprises representatives from Canadian universities and from all fields of science taken in a broad sense.

Each application stands on its own merit and a high standard of scholarship has been rigorously maintained. The numbers of awards are not limited by fields of research or by universities. The task of the Council is made more difficult by the fact that the universities recommend only their best students and hence they must select the very superior candidates from an already high calibre group. In recent years, close to half of the applicants were awarded scholarships. However, about 15% of these awards were not held for various reasons such as unforeseen financial responsibilities, changes in plans, sickness, etc. Over 80% of the scholarships awarded were for study in Canadian universities. In addition, it should be mentioned that many of the students who fail to receive a scholarship and a large number of others are supported under N.R.C. research grants made to members of university staffs.

Those responsible for such an important program are continuously concerned with what has happened to the scholarship holders over the years. Have these scholarships been a good investment for Canada? What has happened to the non-successful group of applicants? Are the methods of selection adequate? In an attempt to shed more light on such questions, this study was undertaken.

Highest degree obtained	*Successful applicants*		*Unsuccessful applicants*		*Totals*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Ph.D.	331	74	132	44	463	62
Master	100	22	115	38	215	29
Bachelor	19	4	53	18	72	9
Totals	450	100	300	100	750	100

Summary A

WHO WAS STUDIED

Obviously, the group selected should be recent enough to reflect present-day operations and large enough to permit meaningful comparisons. Bachelor graduates of the 3-year period from 1949 to 1951 who had applied for a Council graduate scholarship in the years following their first degree were found to have these attributes.

This group is one of the earliest in which most students would by now have completed their training and entered upon careers in science. It also has the advantage of being the largest 3-year group available. Indeed there were more people by far who obtained a Bachelor's degree in science or engineering in these 3 years than in any other 3-year period in the history of Canadian universities, because of the war veterans who graduated in those years in addition to the normal student body.

All applicants for scholarships who had graduated with a bachelor's degree during this period amounted to a group of exactly 900. Current addresses for most of these people were secured from alumni associations, graduate schools which they had attended, and personnel officers of Government departments. Contact was established with approximately 98% of the group, and 96% of those who were sent letters responded to the questionnaire. Altogether, 846 people provided complete data.

WHAT WAS ASKED

Questions asked included: What university granted which degree, in what year, in what field of specialization? Present employment was asked for as at 1 July, 1957, together with name of employer, location of employment, position held, and annual salary effective at that date.

WHAT WAS ALREADY KNOWN

During the period 1949 to 1957 the Council received 1616 applications from the group of 900 students who form the basis for this survey; 80% of these applications were submitted in the four years following their bachelor's degree. About 36% of the applications were for a bursary, 45% for a studentship, and 19% for awards tenable outside Canada.

It should be pointed out however that 152 of these 1616 applications were submitted by students who were granted Research Council of Ontario Scholarships just prior to the date of the N.R.C. scholarship competition. Since it has been the practice not to duplicate these Ontario awards, these applications were not considered by the Council. However, in analyzing the returns of the survey these applicants have been included and considered as successful candidates.

Table I gives the distribution of

Summary B

Highest degree obtained	*Successful applicants*		*Unsuccessful applicants*		*Totals*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Ph.D.	19	73	2	12	21	49
Master	6	23	8	47	14	33
Bachelor	1	4	7	41	8	18
Totals	26	100	17	100	43	100

Summary C. Ratio of Ph.D.'s to Applicants

Region B.Sc. degree	*No. of applicants*	*No. of Ph.D.'s*	*% of Ph.D.'s*
Western Provinces	270	165	61
Central Provinces			
McMaster	46	23	50
Toronto	96	74	77
McGill	97	69	71
Montreal	26	12	46
Other universities	156	87	56
Maritime Provinces	58	35	60
Subtotal	749	465	62
Outside Canada	15	12	75
Still studying	82		
Total	846	477	62

applicants by region of bachelor graduation. Nearly 40% of the Canadian applicants for N.R.C. scholarships graduated from universities in Western Canada, where the population is 27% of the Canadian total. The percentage of applicants from Ontario was just slightly lower than the percentage of its population to the rest of Canada, while the percentage of applicants from Quebec and the Atlantic Provinces was considerably below the percentage of population in these provinces. It appears therefore, that Western Canada produces proportionately more graduate students who are interested in our scholarships. However, the graduates of Western universities have perhaps less opportunity for industrial employment in the home area and may thus be more easily influenced to continue their studies. Large eastern universities have probably a greater number of attractive scholarships to offer to their students than western universities.

The percentage of applicants from the Province of Quebec is lower than the percentage of its population but this is to be expected in the French-speaking universities of Quebec, where such excellent work is done in the humanities, law, and medicine, and where, until recently, science and engineering had not been given equal attention. Since 1945 the departments of science of French-speaking universities have expanded very rapidly and the trend seems to indicate that this growth will continue. The same thing is true in the Atlantic Provinces.

Of the 900 students in the survey, 512 were successful in winning one or more N.R.C. or R.C.O. scholarships. Excluding 65 R.C.O. scholarship winners, 447 or 54% of the applicants were successful in winning one or more scholarships from the National Research Council. The percentage of successful applicants from most of the universities is quite close to this over-all percentage.

These 447 successful applicants received a total of 798 N.R.C. scholarships or approximately 1.8 awards each. These 798 awards comprised 232 bursaries, 356 studentships, 85 fellowships (this category was consolidated with studentships in 1955), 67 special scholarships, and 58 postdoctorate overseas fellowships. The following is a breakdown of the 447 students by number of scholarships won. (Column A shows No. of N.R.C. scholarships won by an individual; col. B. shows no. of students who won 1, 2, etc. scholarships).

Category	*Level of education*	*Industry* %	*Government* %	*University* %
Working within 3 years of Bachelor graduation	The majority remained at the Bachelor level	76	17	7
Intent to do post-graduate study	Those who remained at the Bachelor's or Master's level	51	38	11
	Those who attained the Ph.D.	36	29	35

Summary D. Study/Job-Distribution

	Industry %	*Government* %	*University* %	*Total of employed Ph.D.'s* *No.*
Chemists	57	20	23	143
Life scientists	11	38	51	106
Physicists	24	36	40	92
Engineers	53	28	19	62
Mathematicians	17	17	66	18
Totals	36	29	35	421

Summary E. Distribution of Ph.D.'s by Subject

Female applicants

Only 60 of the 900 applicants were women, and a slightly lower percentage was successful in winning N.R.C. scholarships, 48% compared to 54% for male applicants.

A	B	%
1	232	51
2	120	27
3	66	15
4	17	4
5	12	3
Total	447	100

Summary F

Country granting Ph.D.	*N.R.C. Award*	*Employed in Canada*	*U.S.A.*	*Total*
Canada	Given	149	33	182
	Withheld	47	22	69
U.S.A.	Given	48	41	89
	Withheld	19	29	48
U.K. and other	Given	33	6	39
	Withheld	8	1	9
Total		304	132	436

Summary G. Percentage earning more than $7000 per annum

	Bachelors and Masters Canada	*U.S.*	*Doctors* Canada	*U.S.*	*Total* Canada	*U.S.*
Industry	54	91	85	98	66	96
Government	23	—	24	—	23	—
University	0	29	10	17	8	19

INFLUENCE ON ACADEMIC CAREER

Table II gives a distribution of the 846 reporting applicants, classified by highest degree and by year of obtaining highest degree; 477 or 56% have a Ph.D. degree, 290 (34%) went as far as the master's degree, and only 79 (9%) did not go beyond the bachelor's level.

Excluding the reporting applicants whose first application to N.R.C. was for a postdoctorate fellowship (14) and those who were still studying at 1 July, 1957, for a higher degree (82) the Summary Table A was derived.

This study shows that about three quarters of the successful applicants attained the Ph.D., and that a little less than half of the unsuccessful applicants also attained the Ph.D. Similar studies in other countries would be helpful in showing whether this Canadian experience was or was not unusual.

Female applicants

Of the 60 women in the survey, 52 have reported information. Of these 52 applicants 21 or 40% attained the Ph.D. degree. Excluding nine who were still studying for a higher degree, one obtains the distribution in Summary B, which can be compared to Summary A where male and female were grouped together.

Proportionately there were nearly twice as many women as men still studying for a higher degree. We note also that 51% of the women who have completed their studies have not attained the Ph.D. level as compared to 38% for men. This is to be expected as marriage has delayed or changed the plans of many women.

	Industry *U.S.* $	*Industry* *Canada* $	*Canadian Government* $	*Universities* *U.S.* $	*Universities* *Canada* $
Engineers	9,500	8,042	6,950	—	5,875
Physicists	10,000	7,417	6,750	6,583	5,900
Chemists	9,313	7,464	6,786	5,583	5,208
Mathematicians	—	—	—	6,375	5,500
Life scientists	8,000	—	6,327	5,750	5,850

Median Salaries by Subject of Degree and Field of Employment

Region of B.Sc. degree	*No.*	*No. who migrated to* *other regions in Canada*	*No. who migrated to* *U.S.A.*	*% who have migrated*	*No. gained from other regions in Canada*
Western Provinces	147	57	53	75	18
Central Provinces	244	25	59	34	67
Maritime Provinces	34	13	13	77	10
Totals	425	95	125	52	95
Outside Canada	11	4	7		
	436				

Geographic Migration of Applicants Holding a Ph.D. Degree

How far you go depends on where you begin

Excluding those who were still studying at 1 July, 1957 (82), it is found that, among graduates of various Canadian universities who have applied for N.R.C. scholarships, there are highly significant divergences from the over-all proportion of Ph.D.'s. From Summary C the chi-square of 21.04 obtained in testing the homogeneity of ratios of Ph.D.'s to the number of applicants by region of B.Sc. degree, has a chance probability of less than 0.01.

The percentage of Ph.D.'s was highest amongst the graduates of Toronto and McGill. The percentage at the universities in the Western Provinces and the Maritimes was very close to the over-all percentage of 62%.

Table I. Distribution of Applicants and Award Winners by Region of Bachelor Graduation

Region of Bachelor graduation	*No. of applicants* *Total*	*No. of applicants* *Successful*	*Per cent of* *Successful applicants*	*Per cent of* *Applicants by region*	*% of population by region 1951 Census*
Western Provinces					
British Columbia	111	63	56.8	13.8	8.4
Alberta	64	38	59.4	8.0	6.8
Saskatchewan	72	44	61.1	8.9	6.0
Manitoba	71	33	46.8	8.9	5.5
SUBTOTAL	318	178	56.0	39.6	26.7
Ontario					
Western Ontario	48	26	54.2	—	—
McMaster	38	17	44.7	—	—
Toronto	96	56	58.3	—	—
Queen's	59	33	55.9	—	—
Other Ontario	6	—	—	—	—
SUBTOTAL	247	132	53.4	30.7	32.8
Quebec					
McGill	114	55	48.2	—	—
Montreal	30	14	46.7	—	—
Laval	25	15	60.0	—	—
Other Quebec	7	3	42.9	—	—
SUBTOTAL	176	87	49.4	21.9	28.9
Atlantic Provinces	63	35	55.6	7.8	11.6
TOTAL FOR CANADA	804	432	53.7	100.0	100.0
Graduates from outside Canada	31	15	48.4	—	—
Applicants who were awarded R.C.O. Scholarships	65	65	—	—	—
TOTAL	900	512	56.9	—	—

Number of years from the B.Sc. to the Ph.D.

From Table II can be drawn the following table which gives a distribution by the number of years from the Bachelor's to the Doctorate degree. It is assumed that Bachelor degrees are awarded at the end of May and that as many Doctorate degrees are awarded in the first 6 months of the calendar year as in the second 6 months so that the Doctorate degrees are considered to be awarded on 1 July of each calendar year.

No. of years from B.Sc. to Ph.D.	*Awarded B.Sc. in* *1949*	*1950*	*1951*	*Totals*
1.58—2.57			1	1
2.58—3.57	36	26	22	84
3.58—4.57	54	52	44	150
4.58—5.57	35	39	44	118
5.58—6.57	30	26	24	80
6.58—7.57	18	18		36
7.58—8.57	8			8
				477
Still studying	19	28	35	

It is expected that a good percentage of those who were still studying will eventually receive a Ph.D. degree. Therefore, since this table is open at the end, the median appears to be the most suitable measure of the average number of years required for the doctorate degree. We find that the median number of years spent to earn a Ph.D. was 4.6 years from the bachelor's degree.

Applicants who won at least one scholarship needed an average of 4.5

years to earn their Ph.D. The array follows:

No. of years from B.Sc. to Ph.D.	*Successful applicants awarded B.Sc. in* 1949	1950	1951	*Totals*
1.58—2.57			1	1
2.58—3.57	28	21	20	69
3.58—4.57	41	39	31	111
4.58—5.57	22	24	32	78
5.58—6.57	21	20	16	57
6.58—7.57	9	7		16
7.58—8.57	2			2
				334
Still studying	14	9	17	

Under existing regulations, a student may receive a maximum of four scholarships from the time he graduates to the time he completes his Ph.D. These scholarships cover the academic term and they can be supplemented by an additional amount during the summer preceding and also following the academic term. Therefore a student winning an award immediately after obtaining his B.Sc. may receive support for 4.3 years, which should on the average be sufficient time to complete his Ph.D.

On the other hand, unsuccessful applicants took more time, on the average, to complete their Ph.D.'s.

In fact, the median number of years required by unsuccessful applicants was 5.0, nearly 7 months longer than successful applicants.

No. of years from B.Sc. to Ph.D.	*Unsuccessful applicants awarded B.Sc. in* 1949	1950	1951	*Totals*
1.58—2.57				
2.58—3.57	8	5	2	15
3.58—4.57	13	13	13	39
4.58—5.57	13	15	12	40
5.58—6.57	9	6	8	23
6.58—7.57	9	11		20
7.58—8.57	6			6
				143
Still studying	5	19	18	

Year of Highest Degree	*N.R.C. Award*	*Bachelors and Masters* — *Year of Bachelor graduation* 1949	1950	1951	*Doctors* — *Year of Bachelor graduation* 1949	1950	1951
1949	Given	6					
	Withheld	18					
1950	Given	21	8				
	Withheld	12	18				
1951	Given	16	23	7			
	Withheld	16	21	22			
1952	Given	7	20	11	28		
	Withheld	4	18	11	8		
1953	Given	2	6	22	41	21	1
	Withheld		7	18	13	5	
1954	Given	1	1	2	22	39	20
	Withheld	2	9	8	13	13	2
1955	Given			2	21	24	31
	Withheld	3	5	8	9	15	13
1956	Given		2	1	9	20	32
	Withheld	2	2	4	9	6	12
1957	Given			1	2	7	16
	Withheld			2	6	11	8
TOTALS	Given	53	60	46	123	111	100
	Withheld	57	80	73	58	50	35
GRAND TOTALS				369			477

Table II. Reporting Applicants Classified by Highest Degree as at 1 July, 1957

Female Ph.D.'s

Twenty-one women have reported a Ph.D. degree. The median number of years which they required to complete the Ph.D. degree was 5.6, a full year more than men.

Following is a table of central values computed from the above information.

Average No. of Years from B.Sc. to Ph.D.

Group	*Mean*	*Median*	*Mode**
Scholarship winners	4.6	4.5	4.1
All applicants	4.8	4.6	4.1
Unsuccessful applicants	5.2	5.0	5.1
Women applicants	5.3	5.6	6.1

* Central value of class with the highest frequency

Table IIIA. Distribution of Successful and Unsuccessful Applicants by Subject of Highest Degree and Field of Employment

Bachelors and Masters

Subject of highest degree	*N.R.C. Award*	*Employed in* — *Canada* *Ind.*	*Govt.*	*Univ.*	*U.S.A.* *Ind.*	*Govt.*	*Univ.*	*Other*	*Total*
Chemistry	Given	12	7	—	4	—	—	7	30
	Withheld	18	11		3	—	1	15	48
Life sciences	Given	1	13	3	—	—	1	20	38
	Withheld	2	18	7	—	—	2	24	53
Physics	Given	6	11	1	7	—	2	11	38
	Withheld	11	13	2	2	—	—	11	39
Engineering and Applied sciences	Given	16	9	1	2	—	—	15	43
	Withheld	32	8	3	4	—	1	9	57
Mathematics and Statistics	Given	3	3	1	—	—	—	3	10
	Withheld	3	3	3	—	—	—	4	13
TOTALS	Given	38	43	6	13	—	3	56	159
	Withheld	66	53	15	9	—	4	63	210
GRAND TOTALS		104	96	21	22	—	7	119	369

SUBJECT OF HIGHEST DEGREE

Table III gives a distribution of the 846 reporting applicants, classified by subject of highest degree, and by field of employment.

These 846 applicants were divided up as follows:

Subject of highest degree	*No.*	*%*
Chemistry	234	28
Life sciences	231	27
Physics	171	20
Engineering & Applied sciences	168	20
Mathematics & Statistics	42	5
	846	100

At 1 July, 1957, 56% of the reporting applicants had obtained a Ph.D. degree. In chemistry the percentage was 67%, compared with 61% in life sciences, 55% in physics, 45% in mathematics, and only 40% in engineering and applied sciences.

Of those who had not reached the Ph.D. level, 43% were successful in winning at least one scholarship. For each subject of degree the percentage of award winners was about the same as this overall percentage of 43. In fact a comparison by fields showed a chi-square of 1.98 and the chance probability of obtaining this figure is higher than 0.70.

However, the situation is different for those who have a Ph.D. degree. In this case a chi-square of 17.95 was found. The chance probability of obtaining this number is about 0.001. For Ph.D.'s, there are, therefore, highly significant over-all divergences in the percentages of award winners in the various fields of specialization.

The over-all percentage of Ph.D.'s who were successful in winning at least one scholarship was 70%. In chemistry it was 72%, in engineering and applied sciences 71%, and in mathematics 74%. In physics, however, the percentage was 83% whereas it was only 58% in the life sciences. Physicists received significantly more scholarships; students of the life sciences received significantly fewer.

Female applicants

Of the 52 female reporting applicants, 62% were in the life sciences and 24% in chemistry.

Subject of highest degree	*N.R.C. Award*	*Employed in*							
		Canada			*U.S.A.*			*Other*	*Total*
		Ind.	*Govt.*	*Univ.*	*Ind.*	*Govt.*	*Univ.*		
Chemistry	Given	31	20	17	26	1	8	10	113
	Withheld	7	6	3	18	1	5	3	43
Life sciences	Given	2	22	30	6	—	5	16	81
	Withheld	—	17	10	4	1	9	18	59
Physics	Given	6	30	21	9	—	10	2	78
	Withheld	2	3	5	5	—	1	—	16
Engineering and Applied sciences	Given	17	14	4	7	—	1	5	48
	Withheld	6	3	5	3	—	2	1	20
Mathematics and Statistics	Given	—	3	5	1	—	4	1	14
	Withheld	2	—	2	—	—	1	—	5
TOTALS	Given	56	89	77	49	1	28	34	334
	Withheld	17	29	25	30	2	18	22	143
GRAND TOTALS		73	118	102	79	3	46	56	477

Table IIIB. Doctors

UNIVERSITY GRANTING PH.D. AND SUBJECT OF PH.D.

Table IV gives a distribution of Ph.D.'s by subject of Ph.D. degree and university granting Ph.D.

One observes at once the progress accomplished by the graduate schools of Canadian universities; 58% of the Ph.D.'s were given in Canada, 30% in the U.S., and 11% in the U.K.

A comparison by subject of degree and country awarding degree revealed a chi-square of 16.49, the chance probability of which is less than 0.05. There are therefore significant divergences from the above over-all percentages. Proportionately fewer people earned Canadian Ph.D.'s in mathematics and engineering. They preferred American universities in mathematics and U.K. universities in engineering. On the other hand, proportionately more people took Canadian Ph.D.'s in physics and fewer went to the U.S. Also, proportionately more people earned American Ph.D.'s in the life sciences with proportionately fewer going to the U.K.

One third of the 278 Ph.D. degrees taken in Canada were awarded by McGill University, and 27% by the University of Toronto. If we exclude these two universities we find that the American universities have awarded more Ph.D's than all the remaining Canadian universities.

The favourite American universities are Wisconsin, M.I.T., Cornell, and Illinois. One third of the 145 Ph.D.'s taken in the U.S. were awarded by these universities.

More than half of the 53 Ph.D.'s awarded in the U.K. were from Cambridge and London University.

Following are the universities which awarded the largest percentage of degrees for each subject of degree:

In the field of chemistry, 26% of the Ph.D's were taken at McGill, 12% at Toronto, 6% at New Brunswick, and 6% at Cambridge.

In physics, Toronto accounted for

Table IV. Reporting Applicants Classified by University of Ph.D. and Subject of Ph.D.

University of Ph.D.	*Chemistry*	*Physics*	*Life sciences*	*Engineering and Applied sc.*	*Math. and Stat.*	*Total*
Canada						
U.B.C.	1	12	6	1	1	21
Other West	8	3	13	—	—	24
Toronto	18	18	18	17	3	74
Other Ont	5	11	18	3	—	37
McGill	41	14	25	10	2	92
Mont. and Laval	13	3	3	2	—	21
New Brunswick	9	—	—	—	—	9
	95	61	83	33	6	278
U.S.A.						
Wisconsin	1	1	7	6	—	15
M.I.T.	4	5	—	3	—	12
Cornell	3	—	7	1	—	11
Illinois	6	3	1	—	—	10
Princeton	1	2	—	3	2	8
California	2	2	2	1	1	8
Harvard	4	—	1	—	2	7
Michigan	—	—	5	1	1	7
Minnesota	1	—	5	1	—	7
Yale	—	3	2	1	—	6
Other U.S.A.	22	5	8	6	3	54
	44	21	48	23	9	145
U.K.						
Cambridge	9	3	2	—	2	16
London	3	1	4	5	—	13
Birmingham	—	2	—	4	—	6
Oxford	3	2	1	—	—	6
Other U.K.	2	4	2	3	1	12
Amsterdam	—	—	—	—	1	1
	17	12	9	12	4	54
GRAND TOTALS	156	94	140	68	19	477

19% of the Ph.D.'s; McGill, 15%; British Columbia, 13%; and M.I.T., 5%.

In life sciences, 18% of the Ph.D.'s were awarded by McGill, 13% by Toronto, 5% by Wisconsin, and 5% by Cornell.

In engineering and applied sciences, 25% of the Ph.D.'s were taken at Toronto, 15% at McGill, 9% at Wisconsin, and 7% at London University.

In mathematics and statistics, Toronto awarded three of the 19 Ph.D.'s; and McGill, Princeton, Harvard, and Cambridge awarded two each.

COUNTRY AND FIELD OF EMPLOYMENT

Turning back to Table III, the 175 reporting applicants who are not classified as "employed" in Canada or the U.S. were divided as follows:

	Masters and Bachelors	*Doctors*
Studying science	82	
Postdoctorate Fellows in Overseas Labs		16
Medical Residents and Interns		12
Postdoctorate Fellows in Govt. Labs		6
Self-employed	10	6
Employed overseas	7	3
Housewives	10	3
Unemployed	4	8
Deceased	6	2
	119	56

Of those who had not reached the Ph.D. level and who were employed at 1 July, 1957, only 12% have taken up positions in the U.S. In Canada and the U.S., 51% were employed in industry, 38% in the Canadian government (Federal, Provincial, or Municipal) and only 11% in universities and other educational institutions.

The situation is quite different for those who attained the Ph.D. degree. Nearly one-third (30%) were employed in the U.S. In Canada and the U.S., 36% were in industry, 29% in the government, and 35% in universities. We must keep in mind that this distribution amongst industry, government, and university applies to a very special group of people — those who attained the Ph.D. degrees. It is very interesting to look at the distribution of all graduates of science and engineering of a given year. In 1957 the Department of Labour queried 2563 science and engineering graduates of 1954 and received replies from 1706 of them. Of these, 1425 were working and most of the rest were still studying. The distribution was 76% in industry, 17% in government, and 7% in universities and educational fields.

Summary D shows at once the difference brought about by the *intent* to study.

University of Ph.D.	CANADA *Ind.*	CANADA *Govt.*	CANADA *Univ.*	U.S. *Ind.*	U.S. *Govt.*	U.S. *Univ.*	*Total Ph.D.'s*
Canada							
McGill	20	18	19	17	1	4	79
Toronto	18	22	15	7	0	5	67
British Columbia	1	6	8	2	0	1	18
New Brunswick	3	1	0	3	0	2	9
Other Western	2	11	4	2	1	1	21
Other Ontario	2	12	10	3	0	2	29
Mont. and Laval	3	6	7	1	0	0	17
TOTAL	49	76	63	35	2	15	240
United States							
Wisconsin	4	7	2	0	0	1	14
M.I.T.	2	0	2	4	0	4	12
Cornell	0	2	1	6	0	1	10
Illinois	2	0	1	5	0	2	10
Princeton	1	1	2	2	0	2	8
California	0	2	3	1	0	2	8
Harvard	2	0	2	1	0	2	7
Michigan	0	1	2	1	0	3	7
Minnesota	1	1	0	2	0	2	6
Yale	0	2	2	0	0	2	6
Other U.S.	6	6	8	18	1	7	46
TOTAL	18	22	25	40	1	28	134
United Kingdom							
Cambridge	1	4	6	2	0	0	13
London	3	8	1	0	0	1	13
Birmingham	2	2	0	1	0	1	6
Oxford	0	2	3	0	0	0	5
Other U.K.	0	4	4	1	0	0	9
Amsterdam	0	0	0	0	0	1	1
TOTAL	6	20	14	4	0	3	47
GRAND TOTAL	73	118	102	79	3	46	421

Table V. Reporting Applicants Classified by University of Ph.D. and Field of Employment

The study shows that the more postgraduate studying done, the more likely one is to end up teaching. The better education one has, the more one will seek interest in work, and the less importance one will attach to salary.

Although 41% of the employed applicants who have not attained the Ph.D. level have won awards, only 29% of those employed in Canadian universities were scholarship winners. On the other hand, 59% of the non-Ph.D.'s employed in American industry were scholarship winners.

Of the Ph.D.'s employed in Canada, 76% were scholarship winners compared to 61% for those employed in the U.S. This lower percentage of N.R.C. scholarship winners employed in the U.S. may be explained by the number of unsuccessful applicants obtaining support afterwards from U.S. universities. As Summary F shows, 60% of the unsuccessful applicants taking a Ph.D. in the U.S. have not returned to Canada. Also, the higher percentage of N.R.C. Scholarship winners employed in Canada may indicate a slight preference for N.R.C. awardees. Perhaps N.R.C. awards mean more in Canada.

COUNTRY AND FIELD OF EMPLOYMENT BY SUBJECT OF HIGHEST DEGREE

Again from Table III, a chi-square analysis of successful and unsuccessful scholarship applicants who earned a Ph.D. degree, by country of employment and subject of degree, shows highly significant over-all divergences: 60% of the unsuccessful applicants in chemistry were employed in the United States as compared with the over-all percentage of 30%. On the other hand, only 17% of the successful applicants in the life sciences were employed in the United States.

It appears that Canada loses proportionately more Ph.D.'s in chemistry than in any other field. Industry is responsible for this loss. In fact, in each of the fields of chemistry, physics, and life sciences there were more people employed in American industry than in Canadian industry.

It has been seen that 36% of the employed Ph.D.'s were in industry, 29% in the government, and 35% in universities. However, for each subject of degree there are highly significant divergences from these overall percentages.

Summary E shows the percentage

of Ph.D.'s in each field of employment by subject of degree.

As shown in Summary E, 57% of the chemists and 53% of the engineers were in industry, while 51% of the life scientists were employed in universities. On the other hand, only 11% of the life scientists were in industry and 19% of the engineers were in universities.

In other words, if one has a Ph.D. in chemistry or in engineering and applied sciences, chances are he will work in industry. If one is a life scientist or a mathematician, more than 50% of the time he will be employed in a university. As for physicists, in comparison to the over-all percentage, slightly more people were employed in the government and universities than in industry.

COUNTRY AND FIELD OF EMPLOYMENT BY UNIVERSITY GRANTING PH.D.

Table V shows that 70% of the "employed" Ph.D.'s were located in Canada. Divergences from this over-all percentage are found when looking at the country granting the Ph.D. degree. In fact 78% of those who received their Ph.D. in Canada were located in Canada, whereas only 49% of those who studied in the U.S. have come back to Canada. Of the 46 people who received their Ph.D. degree in the U.K., 87% have returned to Canada.

There are no significant differences in the proportion of those who remained in Canada amongst the Ph.D.'s from the various Canadian universities. However, of the nine Ph.D.'s given at the University of New Brunswick only four remained in Canada, while 16 of the 17 Ph.D.'s from Laval and Montreal universities were located in Canada.

Not quite a third of the Ph.D.'s from M.I.T., Cornell, or Illinois returned to Canada. However, 13 of the 14 Ph.D.'s from Wisconsin came back.

The Ph.D.'s from Canadian universities were nearly equally divided amongst industry, government, and universities, but there are significant divergences from this over-all distribution. Considering the following four groups of universities: Western Canadian universities, McGill and Toronto, other Ontario universities, and other Quebec universities plus New Brunswick, we obtain a chi-square of 13.65 the chance probability of which is less than 0.05.

Proportionately fewer Ph.D.'s from Western Canadian universities have entered industry and more have taken government positions. The same is true, to a lesser extent, of Ph.D.'s from Ontario universities (excluding University of Toronto). Proportionately more Toronto and McGill Ph.D.'s have accepted positions in industry and fewer were employed by the government. This is to be expected, since it is well known that industries concentrate their recruiting program on the two largest Eastern universities. The distribution of Ph.D.'s from New Brunswick and Quebec universities (excluding McGill) was close to the over-all distribution.

Of those who have received the Ph.D. from American universities, 43% were employed in industry, 40% were in universities, and only 17% were in the government, largely because a higher percentage of this group was employed in the U.S., and Canadian citizens are excluded from American government posts.

Of the Ph.D.'s from the U.K., 43% were working in the government, 35% were in universities, and 22% in industry.

INFLUENCE OF N.R.C. AWARDS ON LOCATION OF PH.D.'S

Summary F shows the distribution of award winners and unsuccessful applicants by country of employment and by country in which the Ph.D. degree was taken.

Nearly three-quarters of the scholarship winners in Summary F were located in Canada. The percentage was 82% for those who took their Ph.D. in Canada, 85% for those who went to the U.K., and only 54% for those who studied in the U.S.

On the other hand, 58% of the unsuccessful applicants who earned a Ph.D. were located in Canada. The percentage was 68% for those who received their Ph.D. in Canada, and only 40% for those who went to the U.S.

It appears that N.R.C. awards have a marked influence both in retaining Ph.D.'s in the country and in their

Table VI. Distribution of 667 Reporting Applicants Classified by Highest Degree, Field of Employment, and Salary Range as at 1 July, 1957

	Bachelors and Masters employed in				*Doctors employed in*			
Salary	*Canada*		*U.S.A.*		*Canada*		*U.S.A.*	
per annum	*N.R.C. awards* Given	*With-held*	*N.R.C. awards* Given	*With-held*	*N.R.C. awards* Given	*With-held*	*N.R.C. awards* Given	*With-held*
Industry								
10000 and above....	1	1	2	4	3	3	15	8
9000—9999.......	2	4	3	1	2	2	16	8
8000—8999.......	9	6	3	3	11	4	12	11
7000—7999.......	11	22	3	1	29	6	5	2
6000—6999.......	10	19	1	—	8	1	1	—
5000—5999.......	4	11	—	—	—	1	—	1
Below 5000........	1	3	1	—	1	—	—	—
TOTAL..........	38	66	13	9	54**	17	49	30
Government								
10000 and above....	—	2			—	—	—	1
9000—9999.......	1	—			—	—	—	—
8000—8999.......	1	2			2	—	1	1
7000—7999.......	9	7			20	6	—	—
6000—6999.......	19	17			57	18	—	—
5000—5999.......	11	17			10	5	—	—
Below 5000........	2	8			—	—	—	—
TOTAL..........	43	53			89	29	1	2
University								
10000 and above....	—	—	—	—	—	—	—	—
9000—9999.......	—	—	—	—	—	—	—	—
8000—8999.......	—	—	—	—	2	1	1	—
7000—7999.......	—	—	—	2	5	2	4	3
6000—6999.......	1	1	—	1	21	5	12	3
5000—5999.......	3	10	—	—	28	11	7	5
Below 5000........	2	4	3	1	20	5	4	7
TOTAL..........	6	15	3	4	76*	24*	28	18
GRAND TOTAL........	87	134	16	13	219	70	78	50

** Excludes 2 who did not report their salary.
* Excludes 1 who did not report his salary.

return to Canada after study in the U.S.

MIGRATION OF APPLICANTS

Of the applicants who attained the Ph.D. degree more than half were located in other regions than those in which they obtained their Bachelor's degree.

The highest percentage of migration of Ph.D.'s from region of Bachelor's degree was at the University of New Brunswick, 100%; Dalhousie, 82%; and British Columbia, 82%. On the other hand the lowest percentages were found at universities in Quebec: Laval, 0%; Montreal, 18%; and McGill, 33%.

Nearly two thirds of those who obtained their B.Sc. degree outside Canada and who have a Ph.D. degree have gone to the U.S. as compared to 29% for graduates of Canadian universities.

Of those who have not attained the Ph.D. level, only one third have migrated from the regions in which they graduated.

SALARIES

Of the 846 reporting applicants, 175 were not in regular employment (students, self-employed, overseas workers, housewives, etc.) and 671 were employed in either Canada or in the United States. Four of those employed failed to report salary, leaving 667 people on which to base a salary study.

Computing from Table VI, the percentage of applicants earning more than $7000 per annum is shown in Summary G.

In Canada, the gap between salaries in government and those in industry is apparent; it is much larger for Ph.D.'s than for masters or bachelors. Of course, Canadian citizens are not employed in American government posts but a comparison with American salary studies[1] shows that the spread between industry and government is greater in the U.S.A. than it is in Canada.

Canadian university salaries were much below salaries in the government and industry. Nearly one quarter of the Ph.D.'s employed in universities were earning less than $5000. The situation is reversed in Russia where a professional chair in a university carries the highest remuneration in the state.

Of the 667 reporting applicants, 40 had an income in excess of $10,000 and only 10 of them were employed in Canada.

Country	*Field*	*No. of Ph.D.'s*	*Lower quartile*	*Median*	*Upper quartile*
	(a) All Ph.D.'s				
Canada	Industry	71	7161	7625	8330
	Government	118	6269	6677	6974
	University	100	5000	5696	6367
	TOTAL	289	5882	6642	7348
U.S.A.	Industry	79	8410	9268	10125
	Government	3	—	—	—
	University	46	5042	6000	6650
	TOTAL	128	6400	8333	9600
	(b) Scholarship winners				
Canada	Industry	54	7150	7607	8139
	Government	89	6322	6744	6997
	University	76	4967	5688	6375
	TOTAL	219	5915	6659	7356
U.S.A.	Industry	49	8521	9406	10153
	Government	1	—	—	—
	University	28	5375	6188	6750
	TOTAL	78	6550	8375	9719
	(c) Unsuccessful applicants				
Canada	Industry	17	7188	8125	9188
	Government	29	6141	6575	6938
	University	24	5125	5714	6333
	TOTAL	70	5813	6577	7325
U.S.A.	Industry	30	8321	9083	10063
	Government	2	—	—	—
	University	18	4750	5500	6375
	TOTAL	50	5917	8286	9375

Table VII(A). Salary Quartiles of Reporting Applicants by Field of Employment

The remainder of this section deals only with salaries of Ph.D.'s and it is important to remember that, on the average, these people obtained their Ph.D. degree only 2½ years ago. Table VII gives salaries for the 417 Ph.D.'s by country and field of employment.

As shown in Table VII (*a*), the median salary of Ph.D.'s employed in Canada was $6642. The median salary in industry was about $1000 higher than that in the government, which in turn was approximately $1000 higher than in the universities.[2] In the U.S.A., the median salary of Ph.D.'s was $8333, with industry more than $3000 higher than the universities. The difference between the median salary in American and Canadian industry was about $1600, while the difference between American and Canadian universities was only $400. In American industry, 25% of the Ph.D.'s were earning more than $10,125 per annum.

1 1957. National Survey of Professional Scientific Salaries. Los Alamos Scientific Laboratory of the University of California, Los Alamos, New Mexico.

2 These findings are in close agreement with the 1957 Survey of Professional Salaries for Engineers and Scientists, a confidential report published by the Division of Administration and Awards of the National Research Council.

Table VII (*a*) also shows that for those employed in Canada there was no significant difference in salary between scholarship winners and unsuccessful applicants. Scholarship winners working in the United States had a slight advantage over the unsuccessful applicants.

Table VII (*b*) shows that the best paid Ph.D.'s were the engineers, followed by the chemists and physicists. The median salary of engineers employed in Canada was $7281 compared to $9313 in the U.S. For chemists, the figures were $6926 and $8750, for physicists $6667 and $8250, and for life scientists $6143 and $6625. The discrepancies between disciplines are accounted for to a great extent by the percentages employed in industry. As Summary E shows, more than half of the engineers and chemists were in industry, while only one quarter of the physicists were so employed.

In Canadian industry, problems of supply and demand have resulted in salaries for the engineers being some distance ahead of those for chemists and physicists. Government salaries were more nearly equalized, but the salaries of life scientists were considerably below the others. In Canadian universities, salaries were also nearly the same but this time the salaries of chemists were considerably below.

In American industry the median salary for Ph.D.'s in physics was somewhat higher than those of engineers and chemists, while the life scientists were at the bottom. In American universities, the physicists and the mathematicians were the highest paid and, as in Canadian universities, the chemists were the lowest.

The median salary of life scientists in Canadian universities ($5850) was higher than in American universities ($5750); this is the only instance of a higher median in Canada than in the U.S.

DISCUSSION

The present study was exploratory. It raises many more questions than it answers, so it may perhaps be regarded as successful in its simple aim of probing *what* happened to our scholarship applicants, whether they obtained an award or not. A much more sophisticated study would be required to find out *why* these things happened.

Even so, it is evident that salary level, while important, is not the only consideration, nor even the principal factor in the complex decisions that these people have made. Canadian government pays its Ph.D.'s at a higher rate than the universities, and Canadian industry in turn pays a good deal better than the government. Yet the Ph.D.'s in question have distributed themselves about equally over these three fields of employment. The U.S.A. pays a good deal more money to people of this class than we do, yet more than two thirds of them preferred to work in Canada, instead of the other way about.

For so valuable a natural resource as young Ph.D.'s, any avoidable loss is serious, and merits study. But the view that this is a simple matter of supply and demand, and easy to manipulate by the device of raising salaries, is not supported by the present work. Gaps of several thousands of dollars will not always, nor even usually, prevent a good man from studying what he wants to study, working where he wants to work, or living where he wants to live. This is probably a very good thing, and one should perhaps be thankful that salary inequalities of this order have not succeeded in distorting the natural pattern. If our young scientists were influenced solely by money, they would all be engineers, happily at work in the industries of the U.S.A.

We must keep in mind, however, that Ph.D.'s in this survey have just begun their careers. Presumably they have chosen their field of employment after having determined where they would find the most interest in their work. However, later on in life, when they have experienced more the problems of supporting a family and maintaining their rank in a society where a lot of importance is attached to material well-being, several may sacrifice, to some extent, their interest, which was their primary motive, for more lucrative employment. It would not be surprising to find that in 10 years from now the pattern which was established at the start will have changed considerably and that salary will have been an important factor in explaining this change. Certainly interests may not have been genuine at first or may change later on. However, Ph.D.'s have spent a good number of years studying and it is reasonable to assume that, in most cases, their interests would be genuine by the time they reach the stage of employment.

Table VII(B). Salary Quartiles of Reporting Applicants by Subject of Highest Degree and Field of Employment

Country	*Field*	*No. of Ph.D.'s*	*Lower quartile*	*Median*	*Upper quartile*
		(*a*) *Chemists*			
Canada	Industry	38	7125	7464	7972
	Government	26	6554	6786	7083
	University	19	4775	5208	5625
	Total	83	5982	6926	7548
U.S.A.	Industry	44	8400	9313	10000
	Government	2	—	—	—
	University	13	4875	5583	6188
	Total	59	7938	8750	9766
		(*b*) *Physicists*			
Canada	Industry	7	7125	7417	10125
	Government	33	6507	6750	6993
	University	26	5188	5900	6750
	Total	66	6068	6667	7208
U.S.A.	Industry	14	8688	10000	10438
	Government	—	—	—	—
	University	11	6125	6583	7063
	Total	25	6708	8250	10054
		(*c*) *Life scientists*			
Canada	Industry	1	—	—	—
	Government	39	5931	6327	6702
	University	40	5000	5850	6438
	Total	80	5632	6143	6632
U.S.A.	Industry	10	7583	8000	8875
	Government	1	—	—	—
	University	14	5083	5750	6417
	Total	25	5406	6625	7958
		(*d*) *Engineers and Geologists*			
Canada	Industry	23	7292	8042	8625
	Government	17	6525	6950	7469
	University	9	5125	5875	6875
	Total	49	6516	7281	7986
U.S.A.	Industry	10	9188	9500	10250
	Government	—	—	—	—
	University	3	—	4875	—
	Total	13	8125	9313	10125
		(*e*) *Mathematicians*			
Canada	Industry	2	—	—	—
	Government	3	—	6375	—
	University	6	5125	5500	6250
	Total	11	5438	6250	7063
U.S.A.	Industry	1	—	—	—
	Government	—	—	—	—
	University	5	6063	6375	6875
	Total	6	6125	6500	7250

DISCUSSION

of Technical Papers and Other Articles

Soil and Foundation Problems of the St. Lawrence Seaway Project

F. L. Peckover, M.E.I.C. and T. G. Tustin, Jr. E.I.C.

Soil Engineering Section, The St. Lawrence Seaway Authority, Montreal.

The Engineering Journal, 1958, Sept., p. 69

Carl B. Crawford, M.E.I.C.*

In view of the extensive use of soil mechanics principles in problems of design and construction of the St. Lawrence Seaway it is gratifying to see that these experiences are to be shared with the engineering profession. The authors have done an excellent job of compressing the highlights of their experiences into such a short paper. In doing this they have undoubtedly had to be ruthless in the elimination of detail.

One important practical problem which arises frequently in winter construction work involves the placing and compaction of soil during cold weather. Perhaps the authors would expand their comments to include details of this operation. Over what total area was it possible to work and at what rate was fill placed? Was the surface frozen between shifts and if so was the frozen material removed? Were chemical additives used?

The evaluation of Standard Penetration Tests is always of much interest and details on their application to the glacial till would be valuable. One would imagine a great variation in N depending on the size and distribution of boulders. How was the value corrected for silt content?

Perhaps it is not possible to do more than generalize on the discovery of water-bearing layers in dyke foundations but field experiences would be of general interest. Similarly the construction procedures adapted for cut-off trenches would be useful. Was sheet piling used and to what effect?

Supplementing the description of settlement observations at the Seaway it may be useful to report the development by the Division of Building Research of the National Research Council of an electrical gauge for measuring the compression of pre-determined layers of the natural soil beneath an embankment without interfering with construction. Details of construction are available from the Division. A series of concrete pads, placed on the natural ground surface before filling and then subsequently sounded by driving rods through the fill, together with a set of the gauges gives a complete picture of deformations at the base of the fill and through the subsoil.

Work by D.B.R. with the Seaway Authority and in other regions has illustrated the great value of the field vane apparatus for assessing the shearing strength of Leda clay. This device should however be used with caution. It performs in the field an undrained or quick-type shear test. It is possible therefore when used in a highly stratified or varied clay that local movement of pore water may occur completely changing the assumed conditions. Furthermore the results of vane tests should not be applied to long term stability problems in heavily over-consolidated clays since the assumption of no drainage does not apply and errors will be on the unsafe side.

It is hoped that the authors will be encouraged to publish further details of their work especially in connection with their experiences on "glacial till".

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The Authors

Placement and compaction of earth fills in winter on St. Lawrence Seaway construction was only done when unavoidable, and even then such fills were not allowed to remain in critical structures. The total depth of fill for dykes placed during freezing weather in any location was not usually more than 7 or 8 feet.

Provided they were compacted satisfactorily in every respect **before** freezing, fill layers which froze were allowed to remain in place. Chemical additives were not used. These would have had to be mixed with the fill material under heated conditions, adding considerably to the cost of the operation. References to their use can be found in highway literature.

Fill placement was usually in strips about 15 feet in width and approximately 150 to 200 feet in length, depending on weather conditions and the rate of placement. A typical operation with glacial till for dyke construction involved building each strip to the desired elevation before advancing to the next strip. In this manner, the amount of freezing was reduced to a minimum. The frozen surface of each new strip was removed before placement operations were commenced. Considerable judgment and experience are required to ensure a satisfactory job.

The operation is believed feasible only for fills for construction purposes, or those which can be strengthened on the surface or left standing for some months before use. Clay fills may be placed and compacted with less difficulty than granular fills.

In the great majority of instances the use of the standard penetration test was to indicate the relative density of the soil and the consequent difficulty to be expected in excavation and handling. For example, where scrapers were successfully used for excavation, penetration values were lower than where shovels were required.

There were indeed great variations in penetration values in till, as Mr. Crawford surmises. If a sharp increase in the number of blows during the test indicated a possible boulder, the result was discarded. Where a specific application of the test results was required, individual values were never used. There were usually a sufficient number of results available to plot against depth or even apply statistical analysis, permitting a conservative estimate of the average condition of the deposit.

Penetration values were corrected to compensate for the effect on the penetration resistance of the low permeability of the till, due to its silt content. This procedure is outlined in Reference (7) in the paper.

Practically all of the Seaway dykes were founded on glacial till, except at Beauharnois where a low dyke was built on marine clay. On till, foundation soils and water conditions were most effectively and economically investigated by test pits dug with a backhoe. Deposits below the reach of a large machine were usually considered as having a little influence on dyke performance.

Water-bearing layers encountered included coarse-grained alluvium in the river bed, and lenses of pervious material found within the till and sometimes at the till-rock interface. The alluvium, up to 4 feet in depth, was stripped off foundation areas before fill was placed. Pervious lenses in the till were exceptionally met and running sand was very rare. Cutoff trenches were therefore easily excavated under the impervious zone of the dyke, sometimes in conjunction with a deeper drainage ditch on the side of the cutoff next to the cofferdam. Cutoff trenches were backfilled with compacted impervious fill.

Sheet piling was not used as a cutoff in dyke construction. At Beauharnois, a small experimental installation of sheet piling was made through a thin layer of pervious till overlying bedrock, but it was not effective in reducing seepage due to the presence of boulders. A sheet pile wall was driven to rock along the existing power canal dyke, not to eliminate seepage but to offer resistance to piping which might develop through the foundation.

The authors are interested to hear of the development of special equipment by the Division of Building Research to observe the settlement of fills. Along with equipment already used to record the settlement of structures, this should add significantly to existing data on the settlement problem. At the same time, it is worth noting that simple field levelling on fills and structures throughout the course of a construction project can yield data which is most useful in dealing with numerous problems which cannot always be foreseen.

The points made by Mr. Crawford on the limitations of vane testing in assessing the strength of clays are well taken. The general remarks in the paper on this test are intended to apply only to the conditions in which used.

The comments of Mr. Crawford, who is engaged in the investigation of many Canadian construction problems involving soils and foundations, are appreciated, as is the opportunity to give more details on the points of interest which he raises.

POWER REQUIREMENTS FOR COMMERCIAL AIR CONDITIONING SYSTEMS

(Continued from page 57)

duced to the basis of 1,000 sq. ft. of both net and gross floor area. By neglecting (F) entirely and taking the total of (C) instead of the two separate buildings (A) and (B), the facilities provided in them become more or less comparable. The average of these six is shown to be 5.5 horsepower per 1,000 sq. ft. net area, and of the five for which gross areas are available, the average horsepower per 1,000 sq. ft. gross is 3.83. These figures appear to agree fairly closely with those quoted from United States sources which range between 3½ and 4 watts per square foot. Unfortunately, whether or not the unit area quoted is net or gross has not been indicated. The figures given above are fair to be used only in the vicinity of Toronto and Montreal areas. When it is considered that the variable portion of the load as established earlier is about 50% of the total, it will be conceded that geographical location and thence climate have considerable bearing on the horsepower required.

The operation of the air and water handling or distribution equipment is continuous throughout the year during the time of day when the building is occupied and the electrical load is uniform. No diversity factor may be applied to this load. However, the ratio of brake to name-plate horsepower runs about 90%.

The condenser water pumps and cooling tower fans also operate continuously, but considerable fluctuation in load will occur at the refrigeration compressor, even from hour to hour.

Figures 4 and 5 indicate how the dry-bulb temperatures may vary during the day and also how the current input to a compressor changes. The charts cover two typical weeks in July 1954. The wet bulb temperature has a much greater effect on the loading of the compressor than the dry bulb temperature. This may be seen particularly on the 21st and 25th. On the 21st at 2.00 p.m. outdoor conditions were 79° DB, 72° WB, whereas at 3.00 p.m. they were 76° DB, 76° WB, the current input increasing from 1245 to 1440 amp. On the 25th a sharp rise in the wet bulb temperature from 11.00 a.m. to 1.00 p.m. brought about a corresponding sharp increase in current. These typical charts seem to indicate that it is not possible to say at what time of the day a peak electrical load will be attained.

To summarize, a number of factors contribute to the establishment of the electrical requirements created by air conditioning. Of the total, about 50% is due to the internal load generated by lights, business machines and occupants, the remainder arising from solar and transmission gain and ventilation of air. The total load is of the order of 3.5 tons of refrigeration effect per 1,000 sq. ft. of net area at design conditions.

At such a load the total installed motor horsepower must be of the order of 5.5 per 1,000 sq. ft. of net area or 3.85 per 1,000 sq. ft. of gross area.

Only by comparison may figures be made to seem impressive. When it is considered that, prior to the advent of the fully air conditioned building, these same buildings would have been heated and ventilated, at least to the extent of toilet exhaust ventilation, at the expense of certainly not more than 0.5 h.p. per 1,000 sq. ft. of net area, it may be appreciated that air conditioning is having a very great effect on the electrical generation and distribution systems throughout the country.

INSTRUMENTATION IN INDUSTRY

FOODS AND BEVERAGES

CANADA'S FOODS and Beverages industry is the Nation's largest manufacturing industry. Selling value of its products at over $3.8 billion in 1956 represented 17.7 per cent of the value of all Canadian manufactures, while value added by manufacture amounted to 13.7 per cent of all manufacturing production. In 1956 this industry employed 183,000 persons; cost of materials used totalled $2.47 billion, and value added by manufacture amounted to $1.31 billion.

The leading industries of the foods and beverage group, in order of value of annual shipments, expressed in millions of dollars, was as follows in 1956; slaughtering and meat packing, 844.89; dairy products, 551.8; miscellaneous foods, 334.67; bread and bakery products, 306.8; the feeds industry, 250.95; fruit and vegetable preparations, 249.9; flour mills, 221.77; the brewing industry 215.9; fish processing, 169.93; and the distilling industry, 144.4.

Ten-year Increases in Foods Production per Employe

An analysis of statistics for the entire Canadian food industry shows that value added by manufacture per employe in constant dollars had increased in the case of some foods during the decade prior to 1957, despite wage increases which had almost doubled over the same period. This reflects more efficiency in production through mechanization and improved methods. The proportion of this increase in the value produced per employe which can be attributed to instrumentation and automation can only be surmised.

An analysis for each industry within the group shows gains during the ten years for slaughtering and meat packing; miscellaneous foods (mostly tea, coffee); fruit and vegetables preparations; and animal feeds. For the dairy, bakery, flour and cereals, confectionery and carbonated beverage industries there was little change in value added per employe in constant dollars, while for distilling, biscuits, sugar, and fish processing the value actually decreased.

Per Capita Food Expenditures

Retail food prices have been growing steadily over the past 10 years. However, all branches of the food industry have succeeded in minimizing higher costs through greater productivity. In 1955 the proportion of income spent on food ranged between 37.3 per cent for the lower income group and 18.7 per cent for the higher income group.

Food expenditures in 1947 in constant dollars accounted to 28.7 per cent of consumer spending on goods and services. In 1957, with rising incomes the percentage had declined to 25.7 per cent. Yet per capita food expenditures in constant dollars showed a steady increase. Since per capita food intake has not varied much in the past decade, the higher expenditure obviously is due largely to special facilities and services provided by processors and packers.

Computers in the Food Industry

In outlining instrumentation developments and uses in the first two articles of this series covering the chemical manufacturing and the pulp and paper industries, electronic computers were mentioned. Reason for this is that these industries deal mainly with bulk commodities, with a few large consumers and an established pattern of transportation and distribution which varies little from month to month and year to year.

In steel making, metal fabricating, oil, motor-vehicles and in the Food industry, however, there are a number of market areas to be serviced, many warehouses in which materials may be stored and a number of factories in which products may be processed. Here, the costs of transportation, storage, labor and raw materials in each of the different centres may vary. The market conditions in each centre may vary according to certain patterns which can partly be predicted. The problem to be solved is how to schedule production and transportation to obtain a maximum return on the investment. This is an 'operations research' problem.

Computations and calculations required to correlate and vast number of permutations and combinations possible to achieve maximum efficiency soon exceed the ability of the human brain equipped with a desk calculator. Thus the computer takes over. New concepts in management and in operations procedures have been developed. Expressions such as 'linear programing' and 'dynamic programing' are conceived and are developed to maturity by the computer.

There are three new keys to progress that food company management must try to turn. One is automatic warehousing, not only to solve labor and space, but also to improve customer service. Another is automatic data processing with electronic equipment to achieve fast, close control of sales and inventories. The third is the electronic computer that solves impossible problems. Properly manipulated it can take a complex set of facts and come up with simple answers to costly problems in processing, marketing and shipping.

"Electric brain" time can now be rented from major 'brain' manufacturers, at a cost of a few hundred dollars per problem. In some of Canada's largest cities there are large electronic computers installed by industries for their own work, such as Canadian Pacific Railway in Montreal. These computers can be hired on a time rental basis for solving other companies' problems.

Beyond the more common problems for computers, such as payrolls, paychecks, tracing freight cars, actuarial problems for insurance purpose, etc. there are two somewhat different problems involved in linear programming—one is the transportation problem, while the other is the general problem. The first of these revolves around distribution route scheduling, materials handling, sales area functions, crew scheduling, plant location factors, raw materials procurement, and the like.

The other problem is more 'general' than the transportation problem. Problems of this type involve all phases of product line, sales promotion, machine selection, building allocation, raw materials purchasing, process selection and labor use.

Electronic computers are now pinpointing best plant locations, precalculating process and control performance, handling accounting problems, forecasting sales and establishing optimum distribution operations.

What California Packing did with the Computer

Up to the minute facts on sales movement and inventories are essential parts of strategy decisions to counter unforeseen developments before they become cold statistics. California Packing, for example, a pioneer in the use of electronic business controls has achieved unusual results in this direction. Equipped with a pertinent sales analysis carried out by an electronic computer, management is able to have an overall concept of what is happening; to exercise closer control over inventories; to get a quick picture of where sales are headed; and to clear the desks of time-consuming paper work.

Besides these reports on sales and stock that executives receive each Monday morning, the computer is used to produce an inventory and sales report for each variety, size and package. It produces complete weekly rundowns on activities of each Calpak broker; and a similar weekly rundown for each buyer served by each broker. Clearly, the computer's major contributions to sales analysis are in terms of scope and capacity. Considering the amount of data that can be digested and assembled into useful information, no operating report or statistic need be considered so complex that it is impracticable to compile it.

Automatic Control in Food Plants*

A prime factor in boosting food plant productivity in America has been the dramatic switch in the past few years from manual supervision to automatic control. Electro magnetic monitors will operate through relays to activate electric, pneumatic or hydraulic servo-mechanisms to perform man-saving operations such as freezer loading, and recently developed static controls accomplish many functions formerly requiring high-speed relays with many multiple contacts.

X-ray level detectors assure proper container fill, while photo-cells are extensively used as "no-container-no-fill" devices, to monitor flow on conveyors. Through in-stream analysis, process instrumentation is rapidly achieving direct quality control of products right on the production line, where it operates most efficiently and economically. Control of process variables such as temperature, pH, pressure and flow is now virtually standard practice in efficiently operated food plants.

*Reproduced in part from an article in FOOD ENGINEERING, August, 1958.

Continuous automatic control of product quality factors is being achieved by triple-acting instrument systems that detect deviations from pre-set quality standards; apply instantaneous corrections and record results.

Density

Density of citrus concentrate is controlled by in-line refractory systems. Combining optical and electronic operation, they analyze the process steam 480 times per second in controlling and recording the blending of evaporation output and the required cutback juice.

Gamma-ray Transmission

Gamma-ray transmission is being used to control density of liquids, slurries, granules and powders. Another radiation device for use with small diameter pipes employs a source and detecting cell. Output signals can actuate valves, pumps or waters in a closed loop control system.

Viscosity

Consistency of apple-sauce is continuously controlled by a unit employing a hydraulically balanced flow bridge. This system is also applicable to baby-foods, tomato products and corn in cream style.

Better viscosity is being monitored in-stream by a spinning-bob viscosimeter that regulates addition of the dry and liquid ingredients to a blender.

Moisture

Moisture in free-flowing solids is controlled by an instrument operating on the capacitance-bridge principle. Another electronically controlled conveyor line unit measures and records moisture in cereals and baked goods, unaffected by variations in frequency or voltage. Nuclear-magnetic resonance of hydrogen atoms in water offers promise as an in-stream-control property.

Other Controls

Hydrogen's absorption of radio-frequency energy under controlled conditions give a 30-second moisture analysis. Infra-red spectrography is also a powerful tool for rapid identification and measurement of organic matter. Direct control of product quality is offered by a new unit that performs actual chemical analysis on the production line for sugars, protein, vitamins, salts and metals. X-rays are being used to regulate thickness of extruded materials such as dough. Rays do not contaminate the product or alter food values.

Particle size control is a unique application of a new in-stream instrument that charts size-frequency data for monitoring the operation of the size-reduction equipment. Instrument operation is based on difference in conductivity between particles and a fluid suspension medium.

Various Applications of Instrumentation

In an Ice Cream Plant: In a large U.S. ice cream plant an automatic bundler accumulates two half-gallon packages as they are conveyed from filler-wraps, and seals them in kraft paper. Then a coder imprints flavors on three sides. Sealed packages are conveyed to a freezing tunnel.

Actuated by electric motors and hydraulic devices, a new automatic pallet unloader automatically discharges cases to a conveyor at 25/30 per minute. It employs panel-mounted controls to regulate operating sequence:

Full pallets deposited at the loading station by lift truck are advanced to a dispersing table where a clamp holds all but the bottom tier. Bottom cases can move to discharge conveyor in simple file until all cases are unloaded. Empty pallets are automatically slacked.

A versatile liquid meter equipped with a 'memory' offers flexibility in quality control with less operator attention. Called a repeating autostop, it delivers the same quantity each time the valve is opened and shuts off automatically when a preset quantity is reached. Applications include batching of water, syrups and oils as well as production line filling of barrels or drums.

In a Sugar Plant: A large American sugar company is realizing great efficiency and economy by installing instrumentation costing more than $1 million. It has switched from its former batch operations which required considerable manual handling to a smooth fully mechanized continuous production flow. Multipurpose automatic timers cycle operations to level out production, open and close prime elements, control key factors and carry out additional centrifugal operations.

For melting, from a control panel sugars centrifuged from the mingler and vacuum pan are melted for subsequent refining into liquid sugars. There is control at this stage of flow rates and syrup density. The new robot timing changeover has brought greater uniformity in the proportioning of materials for more uniform quality at a labor savings.

In a Bakery: In a large new bakery a dual electrical system guards against plant shutdowns. A large console automatically draws materials from storage tanks, weighs and delivers them according to predetermined formulas.

Irradiation of Packaged Food: U.S. Army's new food radiations centre in California has a 24 million electron-volt liner accelerator which penetrates 6 inches of packaged food with ionizing radiation. The machine is the highest average-power accelerator ever built. Armed forces will need ready sources of imperishable perishables in the event of a fast moving atomic war.

TV Aids Flow Control: Industrial TV has been successful beyond expectations at a Hawaiian sugar plantation. Here the camera views flow and spread of sugar cane being conveyed from the washing plant to the mill. The picture is transmitted to the monitor where an operator regulated the volume of flow. The TV eliminated the need for a watcher.

Grocery store orders can be read photo-electrically, then converted to audible signals that go by phone to a central warehouse to be tape-recorded, decoded and fed into data-handling units. The system was 'nvented by IT & T.

Replies to Food Questionnaire

Replies received from various food industries to a questionnaire relative to instrumentation in their plants, were received from almost every type of food manufacturer.

With few exceptions these plants purchase their electrical power supply. The majority check consumption of power with their own instruments, yet one of Canada's largest meat packing industries with plants all across Canada relies entirely on the utility metering records.

Generally, separate steam plants for heating and power are not maintained. One flour and cereal manufacturer and a confectionery manufacturer who develop most of their own hydraulic power have separate steam plants. Another large meat packing company which purchases its power indicated that it produces steam separately in some of its several plants, while a supermarket chain which uses limited supplies of power makes its steam separately.

Main Purpose and Uses of Instruments

Instruments most commonly used are self-correcting feedback servomechanisms of the mechanical, electronic or electro-mechanical type, or those for continuously recording changes in physical or chemical phenomena (such as a recording pyrometer), or to display a physical or chemical phenomenon (such as a pressure indicator or pH meter).

The main purposes for which instrumentation is used is for achieving better quality, to provide continuous records of operations, to economize in fuel consumption, to regulate pressure or flow, to reduce labor and to provide central supervision for diverse operations, in that order of importance. They are used to count or measure, to provide supervisory warning, to determine rates of flow, to provide records for analysis, and less frequently to measure thickness, composition, to inspect material for flaws, and to measure other physical properties.

Types of instruments most commonly used are recorders for temperature, pressure, humidity, flow, superheating, density and level, and for controlling temperature, pressure, flow, density, consistency, levels, humidity, volume of liquid ingredients and electronic metal detection. They are used for toasting ovens, cookers, dryers, steam tempering, for air conditioning and refrigeration.

Comments from a Modern Processor of Canned Goods

The reply from one of Canada's largest manufacturers of processed food, — soups, canned vegetables, relish, pickles, etc. states "temperature control is used on continuous product heating processes, where a high degree of accuracy is required. Controllers are equipped with all or some of the following control elements: automatic reset, adjustable sensitivity, differential control. The heat-sensitive element (thermo-bulb) is in the heat exchanger effluent product pipe, and the controller operates the steam valve. Retorts are operated by similar controllers and differential control is not needed. The thermo-bulb is installed in the steam jacket of the retort. Pneumatic controllers are used for temperature control only."

"Besides a variety of pressure-reducing valves on steam and water lines, pressure controllers are used on long product lines as a safety device between two positive displacement pumps. The pressure-sensitive element is a stainless steel diaphragm in the product line. The pneumatic controller operates a valve to the run-off tanks. Differential pressure type flow meters cannot be used in food processing, since calibration is too complicated, and sometimes not possible without interrupting production, moreover these flow meters often do not meet sanitary standards."

"Tests with magnetic-type flow meters, with an electronic recorder-integrator, are of very recent date but look promising. They do not need calibration but do need very careful and complicated zero-adjustment. Positive displacement-type flow-meters have also been used recently. If the problem of wear can be solved, this type may be another step forward to solving the problem of flow control and metering in the food industry."

"Density control is effected by converting the weight of a constant volume of product into an air signal, which operates a mixing valve. Tests with radioactive penetration have been anticipated but not yet tried. Though no general way of measuring consistency is accepted, relative values are obtained by 'flow-bridge' instruments. However, tests must be made from case to case if this method is applicable. For level-control, besides the well-known float and electro-probe level controllers, radioactive sources and radiation indicators (geiger counters) are successfully used for level indication of high accuracy in storage vessels, where all other methods of level detection have failed completely".

Comments from Coffee and Cereal Producers

A prominent Canadian tea and coffee producer states that for coffee roasting, electronic controllers are used which complete the coffee roasting cycle automatically. These are basically potentiometer temperature recorders, with built-in control switches. Thermistor probe controllers are used on coffee pouch-making machines to ensure accurate heat control.

A flour, feed and cereals manufacturer has electronic recording temperature controllers on his toasting ovens, air operated controllers on his cookers, puffing guns, dryers and for wheat tempering. Thermo-hydraulic control is used on holding tanks for animal fats, molasses, shortening and hot water. For bin level indicators, proportioning, speed control, moisture meters etc. electronic controls and relays and 'electric-eyes' are used.

Purchasing of Instruments

Practically all replies indicated instrument requirements were determined by the company's own staff. In the case of a few producers operating a number of smaller, widely separated plants, assistance and advice is sought from consultants or instrument makers. For specifying and recommending instrument purchases the general rule is to rely on the Company's engineering department or plant maintenance department, — specifically the maintenance engineer or plant engineer. Purchases are finalized by the central purchasing department or plant, in most cases, though in some cases the engineering department, maintenance department, or both, make the decision.

Instrument Maintenance & Repairs

Few food firms report they have established a preventive maintenance program for instruments. Of those which have such a program, some are firms with a large capital investment and several large plants, while other firms are relatively small. The same is true of those who replied they had no such program. On balance the trend, if there is any, appears to be for larger firms to do preventive maintenance, while in smaller plants there is less occasion for it.

Answers to a question as to what system was used for handling spare parts or replacement units for instruments, indicated no predominent trend. Repair parts are stocked in most instances regardless of the size of the firm. The practice of stocking complete replacements was reported by several large firms conveniently located as to source of supply, while other firms with plants at remote locations do not carry replacements. Only one of the food firms circularized had found that instruments incorporating 'plug-in' features were particularly suitable for use in their plants. Most replies indicated a preference for instruments built on standard commercial lines or modified versions thereof, rather than for having them built to the purchaser's own individual specifications. All firms replying stated they purchased their instruments outright.

Investment in Instruments as Per Cent of Total Investment

As might be expected, there was a wide spread in the capital cost of instruments reported, as between the small firm or plant and the very large industry operating plants in many provinces. Answers ranged all the way from $10,000 for one medium-sized plant making chocolate and cocoa products, to $500,000 in the case of a large meat packing industry with several plants across Canada, or 2% of total fixed assets. A prominent chain of supermarkets has well over $100,000 invested in instruments, or between ¼ and ½ of 1% of total fixed assets.

Nor would it be easy or even possible to strike an average from the replies as to the cost of instruments in terms of the percentage of total capital costs of all plant and equipment. This is understandable because of the wide variation in instrument requirements for various foods and different processes and the extent to which firms have seen fit to adopt automation.

Another of the largest meat-packing firms with several plants, and with overall capital investment in plant and equipment of some $17 million, estimates the value of its instruments at around $100,000, — or three quarters of one per cent. A confectionery firm with one plant states its investment in instruments amounts to 'not more than one per cent of total capital investment'.

Some well-organized food processors treat their instruments as an integral part of each individual project. For example, instead of trucking a product from one building to another, it may be planned to pump the product. The necessary lines, pumps, tanks with pressure level and flow controllers or indicators are designed and estimated. Then total expenditures vs. the expected savings are evaluated. No records are kept on expenditures for instruments separately.

Maintenance and Repair Costs

The annual cost of instrument maintenance also varies widely, depending upon the extent of automation, on the setup of the maintenance crew, and, of course, the size of the plant. The lowest annual maintenance cost reported in terms of investment was that of a flour and cereals processor, whose annual maintenance was half of one per cent of the investment in instruments. A tea and coffee processor estimated his at three-quarters of one per cent. A supermarket chain estimated it at three per cent of instrument value, while a producer of canned specialties with some $50,000 or more invested in instruments thought his maintenance cost was five per cent of his investment in instruments.

Savings Realized through Instrumentation

A chocolate manufacturer states: "most of our instrumentation is of a fairly simple nature. Processes are largely batch type. Instruments primarily reduce supervision and ensure quality of product." A large canner with the most modern equipment, commenting on the time, money and material savings effected by instrumentation, had this to say . . . "Most of our processes would not produce acceptable products if controlled manually. Where manual control is possible and would produce equal results an economic study is made a part of the individual project, and no instrument or equipment will be purchased if a reasonable return on capital investment cannot be shown."

Another, a cereal food firm, points out quality control is very important and difficult to tag with a dollar sign. Without automatic process control industry could not remain alive in the present day competitive market. A firm which produces coffee, cocoa, cereals, gelatine desserts, and pectin from three large plants estimates that in its largest plant savings due to good instrumentation run as high as $200,000 yearly. A flour milling company states it reduces manufacturing costs by 10 per cent by instrumentation, compared with manual operation. A coffee and tea firm points out that one man can operate six coffee roasting machines with automatic controls, while with manual operation three men are needed for the same work.

Time Needed to Write-off Instruments

The general concensus of opinion expressed by firms answering this question seems to be "three years". A dessert, cereal and pet food manufacturer estimated 'three to four years'; a maker of canned specialties answered 'three to five years', while a fish processing, canning and freezing concern with six plants and a capital investment totalling $5 million

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INTERNATIONAL NEWS

GERMANY

NEW OIL PORT. New oil tanker facilities built at Wilhelmshaven in only ten months consist of a 770-yard long jetty from shore out to sea, a 513-yard landing pier that can handle three tankers, and a 230-yard walkway from the end of the pier. Initially 60,000 dwt. tankers will have access through the 50-ft. approach channel, but dredging will later allow the passage of ships of 100,000 dwt. In a second stage, a duplicate pier will be built to increase unloading facilities to six tankers, and annual arrivals from 300 to over 700 vessels. A new 245-mile pipeline, the first major project of its kind in West Germany, will supply refineries, initially at 9 million tons a year, later up to 22 million tons a year. The port was built under considerable difficulties due to severe offshore conditions of wind and tide. A special platform with hydraulically-operated legs, built in Germany in co-operation with the U.S. patent holder, De Yong, of New York, was used for pile driving. The pile driver was so mounted that piles could be driven at any batter towards the platform. Steel piles for the jetty were up to 109 ft. long; bollard piles up to 139 ft. (*Deutsche Korrespondenz*, Bonn.)

SOLAR ENERGY. From studies by the Federal German Meteorological Service it is concluded that industrial use of solar energy is not practical with present techniques for Germany and countries in similar latitudes. However, diffuse sky radiation was found to be somewhat greater than direct solar radiation in these countries. Because of the lower angle of incidence, the effect of diffuse radiation is actually greater in winter than summer. It is recommended that planning for buildings and agriculture should consider site orientation to take advantage of sky-reflected as well as direct solar radiation.

CHEAP HEAT STORAGE. Originally patented in Germany 25 years ago, small heat storage stoves are now being produced in quantity to take advantage of cheap (half day-rate) electrical power during night off-peak hours. Austria, with 125,000 kw. in 1957, exceeded German stove installations (39,000 kw.), and Switzerland is another large user. The table-height stoves, about three feet long, have a magnesite or similar core containing heating elements and surrounded by a thermal insulator. Heated overnight to 300° - 700°C., the cores can supply heat at variable rates throughout the following day or rapidly for shorter periods (e.g., in churches) according to design and the rate of air circulation used. It is estimated that 1-kw. of installed power will heat a room of 300 to 450 cu. ft., depending on general thermal insulation. It is foreseen the sale of off-peak power will become more of a problem when nuclear power-plants are widely introduced. (*Deutsche Korrespondenz*, Bonn.)

EL SALVADOR

HIGHWAY DEVELOPMENT. The World Bank (International Bank for Reconstruction and Development) recently made a loan of $5 million to El Salvador towards a program to provide an all-weather road network through the Pacific coastal plain. This will help construct 21 feeder roads and additional work on the main Coastal Highway, opening up a large potentially rich area and improving communications in the south of the country. Design standards of 18 feeder roads are according to expected traffic; three will be secondary roads to connect with the Inter-American Highway.

UNITED NATIONS

ATOMIC ENERGY. The International Atomic Energy Agency (IAEA) has announced five meetings on peaceful uses of atomic energy during 1959. The first, 25-27 Feb. in Vienna, discussed techniques for determining the distribution of radioisotopes in the human body. In July, a seminar at Saclay, France, will review methods of training specialists in atomic energy techniques. A six-day conference in Warsaw on the application of large radiation sources in industry, especially chemical processes, is scheduled for September. In October, in Vienna, a symposium on radioactive metrology will aim to establish internationally accepted methods of standardization of radioisotopes. Finally, in November, a conference at Monaco will discuss radioactive waste disposal, supplementing the work of an IAEA panel set up in October 1958 to study disposal in the sea. Other international organizations are expected to collaborate (e.g., FAO, UNESCO).

UNITED KINGDOM

TRANSISTORS. The Institution of Electrical Engineers is to hold an international convention on transistors and associated semiconductor devices at Earls Court, London, 21-27 May, 1959, together with a scientific exhibition.

BURIED TRANSFORMER. A new type of buried distribution transformer has been successfully tested. Main advantage of the unit is that it can be installed easily at a load centre without the problem of finding new sites for transformers to reinforce existing supply networks. The unit is contained in a strong tank which can be buried in the ground with only a small ventilating pillar showing above the surface. The air-cooled, 500 kva., 11,000/433 v., three-phase unit uses Class C materials and is fully instrumented. As operating experience is gained, the rating may be increased to around 1500 kva.

GIANT VACUUM CLEANER. Designed by the originators of the vacuum cleaner, a mobile 'cleaner' weighing over 12 tons and more than 22 ft. long has been developed to remove flue dust and grit from large boilers and furnaces. Up to five tons of dust an hour can be extracted from a distance of about 100 ft. and moved by conveyor to disposal vessels. Used on underground flues in a steel plant, savings of 69% in man-hours have been obtained.

MAGNESIA FROM SEA WATER. First developed in 1937, a plant is now producing 150,000 tons of refractory magnesia a year from sea water, at a market price only 70% of that for imported material. Storage tanks totalling 8,000,000 gal. capacity are fed by centrifugal pumps through five pipelines. Calcium bicarbonate is removed before precipitation of the magnesia.

CONTINUOUS CASTING. Twin-strand steel billets and small slabs can be cast at least twice as fast, it is claimed, as by any other known plant on a modified continuous casting machine at Barrow-in-Furness. Two-inch square billets are cast at speeds of 220 to 360 inches a minute. Water sprays solidify the billet before it reaches the withdrawal rolls. Lengths up to 150 ft. have been obtained, though normal practice produces billets up to 30 ft. long.

SOME ASPECTS OF ICE PROBLEMS

(continued from page 54)

deg. as measured during the winters of 1956-57 and 1957-58 respectively. Excavation of the narrows therefore was carried out only to the extent required to reduce head loss and prevent erosion as no ice problem was anticipated and consequently there was no necessity to provide velocities to form and consolidate an ice cover, which meant considerable saving. Actually, whatever the velocity, no ice cover can form as long as a little turbulence is maintained. Should the flow nevertheless be completely stopped, then a cover would form to be melted as soon as operation of the plant is resumed.

The temperature of water at the foot of the gorge, under natural conditions, was sometimes very close to the freezing point, and from there downstream a solid ice sheet formed to the mouth of the river except at the rapid sections. To-day the water in the Bersimis No. 1 tailrace is at a temperature of 2.8 deg. C. when the reservoir is full. This temperature should never drop lower than 2.5 deg. C. above the freezing point at low reservoir level under normal operating conditions. Thence, the water flows to Bersimis No. 2 presently under development where it arrives at a temperature of 0.6 deg. C. after a turbulent 23-mile journey under obviously open water conditions.

Upon completion of Bersimis No. 2 the forebay will become a deeply embanked body of water flowing gently under an ice cover preserving its heat content. Under these new conditions water should reach the No. 2 plant at a temperature somewhat lower than that found at the outlet of No. 1 plant on account of the cold tributary waters between the two developments. In brief, ice will never interfere with the operation of the two plants due to the high temperature of water in winter.

Another example of an intake canal using "warm" water and flowing open the year round as at Bersimis No. 1, is the Shipshaw canal diverting the Saguenay river waters to the Shipshaw plant No. 2. It is 1½ miles long and the flow ranges from 36,000 to 46,000 c.f.s. under an average velocity of 4 to 5 feet per second. The temperature of its water, as observed during the coldest part of the winter of 1954-55, was 0.15 deg. C. above the freezing point at the entrance of the canal. Therefore, no ice problem is to be expected at the Shipshaw plant providing ice from the gently flowing head-pond upstream is prevented from entering the canal.

CONCLUSION

To sum up, rivers whose waters are cooled down to the freezing point are most favourable to the formation of ice of all kinds, and the best means of preventing ice from interfering with plant operation, especially if an important stream is concerned, is by providing a forebay with sufficient cross-sectional area to meet conditions other than the ideal. As regards streams whose waters are never cooled down to the freezing point, their ice problems are usually very easily solved. In resumé, the solution of the ice problem on one stream cannot be applied to any other stream indiscriminately.

PHOTOGRAMMETRY *(continued from page 70)*

at different stages of the construction are also of great assistance in observing erosion and drainage problems and indications of possible land slide, in addition, they will aid in anticipating future maintenance problems.

CONCLUSION

The development during the last few years in the field of photogrammetric engineering has undoubtedly influenced the thinking and the methods of the location engineer. Photogrammetry provides the engineer with data essential to location and design that, not so long ago, had to be collected laboriously on the ground. Information concerning rock and soil types, borrow materials, drainage and land use are obtained quickly from aerial photographs. Furthermore, accurate reconnaissance and detailed topographic plans together with cross sections, profiles, and earth work quantities are compiled photogrammetrically to an accuracy comparable to that of ground survey methods but considerably quicker and less expensive. The benefit of employing an integrated ground and photogrammetric survey together with electronic computations for the determination of pay quantities and slope staking data is not as much in dollars saved but in the convenience of having available a powerful tool which can conveniently take care of the fluctuating volume of surveys and which will provide insurance against costly delays of construction contractor's progress.

We agree with George J. Smith, of McElhanney, McRae, Smith and Nash, consulting engineers and surveyors, Vancouver, who urged the integration of large scale photogrammetry and ground survey in a recent speech. Addressing the Canadian Institute of Surveying in Ottawa, he said:

"It is believed we are facing major developments and improvements in survey instruments and techniques. These changes will be brought about by the rapidly rising costs of surveys using present techniques on the one hand, and on the other hand, by the probable savings made by the use of modern electronic and photogrammetric equipment. Present instruments are expensive, but it can be expected that continual development will lower their cost and raise their precision and degree of utility.

"One wonders what functions these new instruments will perform ten years from now . . . But one thing is certain: if they succeed in lowering the cost of surveying, their effect will be felt from now onward. And this can only be accomplished by the use of sound principles in the relationship of large scale photogrammetry and ground survey and their intelligent integration."

The advantage in using photogrammetric techniques in location work is not simply to substitute for ground methods but to afford economy, speed schedules, improve accuracy, and probably of overriding importance, to supply detail over a broad enough area that the engineer can sample all alternatives to produce the best possible design.

Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

National Aeronautical Establishment

By summer, 1960, the National Aeronautical Establishment of Canada will consist of:—

1. A flight research section and supersonic wind tunnel laboratory at Uplands airport, and
2. A structures section, subsonic wind tunnel, and hypersonics laboratory in the Montreal Road laboratories of NRC.

On January 1, 1959 the National Aeronautical Establishment became a Division of the laboratories of the National Research Council of Canada. In principle, the Establishment came into existence in 1951, charged with the responsibility for integration of government aeronautical research.

Then, nearly all of Canada's aeronautical research and testing facilities were located in the Ottawa laboratories of NRC and were administered by the Division of Mechanical Engineering. The aeronautical laboratories have since grown too large in scope and scale of operations; hence the decision to separate the aeronautical function as a new Division.

There was a parallel and related decision to proceed with the construction of the multi-million dollar supersonic wind tunnel at the NAE site near Uplands airport. Completion of this is scheduled for the summer of 1960.

While it is an intrinsic NRC division, responsible to the president of the Council, NAE has these aids:

The National Aeronautical Research Committee, which guides NAE in broad policy; made up of senior officials of the Defence Research Board, the RCAF, the Department of Transport, the Department of Defence Production, and the National Research Council;

A Technical Advisory Panel, at the technical level of operations; consisting of the director of NAE and representatives of the same agencies;

Associate Committees (being established) whereby industrial representatives can make their views and requirements in research and development known directly to NAE research engineers.

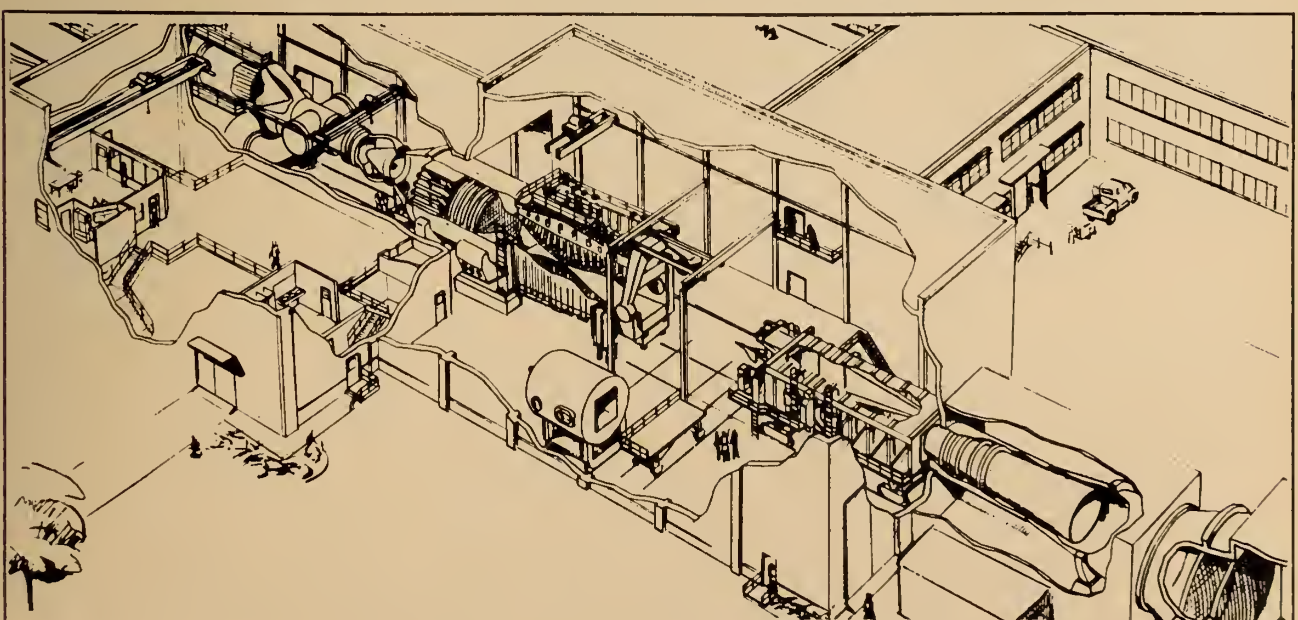
Frank R. Thurston, who was appointed acting director of NAE, is the former head of the structures laboratory of the Division of Mechanical engineering.

He has reported as follows on the research program:

The program of work of the NAE, has been affected by the various defence policy decisions that are pending with respect to air defence. Some of the program has been reoriented towards the more pressing problems of civil aviation. To this end, NAE has organized close technical liaison with the Department of Transport and is working on a variety of problems including vertical takeoff and landing, acoustic noise, runway roughness, air traffic control, airport lighting and a crash position indicator.

The new wind tunnel will greatly increase capacity for aerodynamic research. It will be used for work in a speed range up to a Mach number of about 4.5, and, at a later date by modifications and additions, to

Sketch of new high speed wind tunnel at the National Aeronautical Establishment.



Courtesy of Technical Art Associates, Toronto.

about Mach 15 and temperatures up to about 3000°K. The tunnel is a very advanced piece of equipment and compares favourably with tunnels of similar purpose anywhere in the world. Messrs. Dilworth Ewbank of Toronto have been retained as consulting engineers on design of the tunnel.

The flight research section of NAE has developed specialized equipment for the investigation of slipstream deflection and high lift devices applicable to aircraft design for short take-off and landing or vertical take-off and landing, and is flying contemporary Canadian-built aircraft in programs of research on dynamic stability and on engine reheat.

The structures laboratory has a program of research which includes structural dynamics and dynamic plasticity, structural fatigue with special reference to fatigue crack propagation and fail-safe design, problems of kinetic heating and, as an avenue of research quite new to the laboratory, the study and development of high-temperature-resistant non-metallic structural materials.

The change of the government's aeronautical laboratories to that of an integral, independent Division of the National Research Council, the acting director reports, comes at a time when there is much soul-searching regarding the future of Canada's aviation interests. The facts of the matter are, he says, that Canada will not cease to be an aviation-minded nation. The facts of our geography and distribution of our population preclude it, and the aeronautical sciences have not dried up or run out of potential advancement; they have simply been temporarily eclipsed by the need for a defence-motivated leap frog into astronautics.

"The result of this complexity in the aero-astro-nautical developments of the times is a challenge to level-headed planning", Mr. Thurston says, "and the newly created status of the National Aeronautical Establishment may well be taken as augury that the challenge has been accepted".

Moosonee, an Ocean Port

Moosonee, on James Bay, will be a major ocean port. Ontario's Premier Leslie M. Frost announced this in January, saying that Federal Government cooperation is contemplated. Ontario would proceed with the plan, in any event, so that Ontario will have an outlet on the sea lanes.

The plan is for a $5 million project, including dredging, the building of a dike and construction of docks. It would also involve the building of spur lines by the Ontario Northern Railway and the establishing of marshalling yards. Drilling is already being done to obtain information for location of the harbour.

These advantages have been cited in favour of the project:

The Ontario Northland Railway already connects Moosonee to Cochrane. Natural gas service can easily be extended from Cochrane. There are hydro-electric resources within 100 miles of Moosonee.

Benefits to be derived are headed up by these:

Northern Ontario's potential for development will get closer attention; a great agricultural area will become more accessible by rail and sea.

The port could be used as a supply base for northern defence and radar posts. Traffic in iron ore alone would justify the port, it is said. In the Belcher Islands there is an estimated 4.5 billion tons of iron ore. The new port will make possible its movement by rail to the industrial centre of Ontario, and by sea to other markets.

The Ontario Northern Railway is expected to launch a 20 to 30 million dollar modernization program.

What Goes On

Arctic Supply Operation

An arctic transportation operation of special interest was concluded last fall by the Department of Transport. It was a supply undertaking, by which 77,000 tons of supplies were delivered to defence radar sites, joint arctic weather stations and other outposts. It was the first Canadian sea-supply for DEW line sites in Foxe Basin, 200 miles north of the Arctic Circle. These previously had been served by United States shipping. The fleet also sailed to Mid Canada locations in Hudson Bay, to Frobisher and some 30 other outposts.

The fleet comprised 13 Department of Transport vessels, 22 chartered ships and 125 barges, landing craft and tugs. Throughout the summer they sailed from Montreal and Churchill to as far north as Eureka on Ellesmere Island.

The ships carried passengers to the posts, and the *C. D. Howe* had a special health and welfare mission. It was equipped to carry out medical examinations aboard. The icebreaker, *N. B. McLean* logged 15,500 miles on this voyage.

Soo Bridge

Discussions were held recently relative to the financing of the $18 million international bridge at Sault Ste. Marie. The projected bridge will be approximately 12,000 feet in over-all length, including the approaches from downtown Sault Ste. Marie, Mich., to the outskirts of Sault Ste. Marie, Ont.

Ontario Mineral Production

Mineral production in Ontario during 1958 reached $799 million according to a preliminary Government estimate. This is $50.3 million more than 1957 production.

Ontario's great increase in uranium production was alone more than enough to account for the over-all total increase. The uranium mines in the Elliot Lake and Bancroft areas produced uranium oxide valued at just under $222 million. Uranium held the top production figure. In second place was nickel, at $179 million, its production curtailed by reduction of world stockpiles and by work stoppages. Copper output was worth $72 million; gold production, $90 million; iron ore, $33.3 million.

Demand for Power in N.B.

New Brunswick is planning for the production and use of 600,000 hp. of electrical energy within the next few years. Production of the N.B. Electric Power Commission is now 226,000 hp. But demand is doubling every seven years and, in the immediate future the rate of new demand is expected to jump very sharply. Industrial growth, notably a $50 million oil refinery at Saint John, will demand greater quantities of power.

Ice Bridge for Trucking

An ice-bridge built near Edmonton made the news lately. Design was attributed to Dean R. M. Hardy, M.E.I.C., of University of Alberta.

The ice-bridge was built across the North Saskatchewan River by the use of plastic refrigeration pipes laid across the 150-foot main channel. Natural ice 2 feet thick was reinforced to a total depth of 3 feet.

This bridge allows direct truck transportation of sand and gravel into Edmonton, saving 3½ miles of the alternative route and saving $56,000 in costs.

Trans Canada-Pipe Lines Limited

Four compressor stations will be built by Trans Canada Pipe Lines Limited at an approximate cost of $13 million in 1959. Fifteen sales meter stations costing about $500,000, also will be put into operation.

Three of the new compressor stations will be built by the Northern Ontario Pipe Line Crown Corporation, at Ignace, Geraldton and Hearst, with design and engineering under the supervision of Trans-Canada. The fourth will be built by Trans-Canada near Maple, Ont.

Trans-Canada may now take 5.45 trillion cubic feet of gas from Alberta. The company's original permit from the Alberta Oil and Gas Conservation Board allowed the removal of 4.35 trillion cubic feet, which is under contract for delivery to distribution companies over the next 25 year period. The permit approved in January allows export from Alberta of an additional 1.1 trillion cubic feet during the next 22 years.

Garden City Planned

Webin Community Consultants, a division of Toronto Industrial Leaseholds (1957) Ltd., will convert 374 acres of land in North York Township into a garden city development of family-type rental housing. This land, south of Don Mills, is known as Flemingdon Park. It was acquired last June by Toronto Industrial Leaseholds (1957) Ltd., which is an affiliate of Webb & Knapp (Canada) Limited.

St. John's Harbour

A $13 million expansion of the harbour at St. Johns, Newfoundland, will be completed in the next 4 years. The port will then be able to handle an additional 250,000 tons of general cargo per year.

Main features of the plan are:

- Construction of a large finger wharf and adjacent marginal wharf, providing three additional berths to handle ships up to 10,000-ton capacity.
- Construction of about 2,200 feet of marginal wharves along the north shore to handle coastal shipping.
- The construction of a 617-foot marginal wharf for the ships of the Department of Transport.
- Provision of a boat basin for small boats, with a total berthing arca of 900 feet.
- Removal of harbour obstacles; provision of new mooring locations and tug service.
- Construction of service roads.
- A large modern terminal, built in conjunction with the new deep water berths and wharves in the west end of the harbour, will be linked to the railway yards.

Production Opportunities

A booklet published by the Department of Planning and Development of Ontario, gives a report on "Fabrication Gaps in Canadian Manufacturing Industry", as indicated by imports in excess of $1 million a year. Manufacturers may find here new opportunities for production or expansion.

O.W.R.C. Projects

As the Ontario Water Resources Commission approached the completion of its second full year of operation, March 31, 1959, Chairman A. M. Snider recently reported that OWRC was involved in municipal water and sewage projects throughout the Province having a total value of $30 million. These projects—24 water and 30 sewage—included those completed and in operation, those under construction, and those under OWRC-municipal agreement but still in the pre-construction stage. Water projects were valued at $7.7 million, and sewage $22.6 million.

All were built by the OWRC for the various municipalities and are being operated by or under the Commission's direction. Total value of OWRC projects now in operation is $4.2 million.

Canada Cement Anniversary

Canada Cement Company Limited is celebrating in 1959 fifty years of progress. These years have brought greater production, closer quality control and more economical operation.

Rotary kilns operating in the company plants today are up to 12 feet in diameter and 455 feet in length. Methods now involve high speed rotary quarry drills, large efficient electric shovels and large truck haulage units. Recent developments have added beams, joists, wall panels, roof and floor slabs, to an extensive list of concrete products for construction.

The company's annual capacity is 96 million bags of cement per year. The annual report, issued recently, predicted that in 1959 the plants will be operating at efficient rates, though at somewhat below capacity levels. This is based on preliminary estimates of construction volume.

Queen's University

A fifth year nuclear engineering course, has been available at Queen's University since last fall.

This is a one-year graduate program dealing with basic concepts of nuclear energy and with design of nuclear reactors and industrial applications of nuclear radiations. Information can be obtained from the dean of the faculty of applied science, Queen's University, Kingston.

A symposium on Plastic Design in Steel will be held at Queen's University, June 15-19, 1959. British, American and Canadian speakers are to give papers dealing with: fundamental concepts of plastic design, loads, single and multi-storey frames, connections, plastic behaviour, examples from Britain and the United States, design, foundations, and economics.

Information is available from Dr. H. W. Curran, Director of Extension, Queen's University, Kingston, Ont.

Tandem Accelerator, Chalk River

Atomic Energy of Canada Limited has in service a new, ten million volt atom smasher, known as the tandem accelerator.

It was designed and built by High Voltage Engineering Corporation, Burlington, Mass., and is the first machine of its type; its value is $1 million. It will be able to obtain information on the nuclei of heavier elements than could its predecessor, the Van de Graaff accelerator of 3 million volts.

The tandem accelerator consists of two Van de Graaff accelerators placed end to end, horizontally, in a 23-ton steel pressure tank, which is 34 feet long and eight feet in diameter. The tank contains nitrogen at a pressure of 225 pounds per square inch to insulate the accelerator, preventing escape of the electrical charge.

A beam of particles (for example, protons) is directed into the first of the two units where it is given an energy of five million volts. In the second unit, further acceleration of particles brings the total energy to ten million volts. The beam of particles is then directed against target material (such as magnesium or lead). The particles, penetrating the nuclei of the target atoms, revealing information about their structure.

A shielded building (150 ft. by 60 ft.) houses the accelerator. A separate building contains the control room, and closed circuit television permits observation of the operation.

Month to Month

News of the Institute and the Profession

COMMENT
CORRESPONDENCE
ELECTIONS
AND TRANSFERS

E.I.C. — 1959

ANNUAL GENERAL AND PROFESSIONAL MEETING

The Committee on Technical Operations has arranged a technical program consisting of 43 papers and two panel discussions.

A strong annual meeting committee has been formed in Toronto, under the Chairmanship of E. R. Davis, M.E.I.C. The committee is working in close co-operation with Headquarters to round out the program.

The meeting will be in the new convention wing of the Royal York Hotel, with banquets in the beautiful Canadian Room.

Advance notice of the annual meeting and registration forms will be mailed to all members about the end of March. It is of special interest to note that the dates fall on a Monday, Tuesday and Wednesday. This is a departure from practice imposed by availability of convention bookings.

June 8, 9, 10, 1959, Royal York Hotel, Toronto

CONFEDERATION A Progress Report

There is little that has occurred on Confederation since the meeting of Council at Toronto. There has not been time to complete any of the steps that naturally follow the strong support given by Council to the report of the Joint Committee.

Your chairman has had conversations with the chairman of the Canadian Council committee leading to arrangements for the next meeting of the joint sub-committee.

The EIC members of the sub-committee are at work on a somewhat modified report for consideration of the joint sub-committee. It is proposed that the identical report to the membership will be used for the Canadian Council as well as the Institute.

It should be emphasized that it is not going to be a quick job to get from the committee unanimous agreement on the joint report, but there is every reason to believe it will be achieved within a reasonable time. Members must not expect to receive the ballot immediately, but they may be assured that every effort is being made to have it ready at the earliest possible time.

Engineering Careers

Letter to the Editor

The Engineering Institute of Canada is to be commended for its efforts to establish useful means of liaison between both the prospective Canadian technician and young engineering graduate and the opportunities in the broad field of Canadian engineering.

Had I personally as a youth the opportunity of reading a publication such as your recent edition of "Engineering Careers in Canada," I would have known where I was heading when I sought, and obtained a degree in electrical engineering. Fortunately, somewhere during that four-year course, I discovered that my aptitudes were those of a mechanic, rather than those of an engineer and, at graduation time, that the newspaper profession could be inviting to me.

For young people brought up in small communities and with little opportunity to travel, there is a great need for the broad picture in the choice of a career. That is where I consider your publication has its greatest value.

Enclosed is a tear sheet from the editorial page of *The Telegraph-Journal* containing editorial reference to your publication. The same editorial also appeared in our afternoon paper, *The Evening Times-Globe.*

J. G. Bruce,
Saint John, N.B.
Associate Editor,
The Telegraph-Journal, and
The Evening Times-Globe

Credit is Due

A picture of the *Silver Dart* appeared on page 33 of the February issue.

An apology to the National Geographic Society for failure to include a credit line under that picture, which they very kindly loaned for reproduction in *The Engineering Journal.*

Director of Technical Services

The general secretary of The Engineering Institute of Canada announces the appointment of J. Hance Legere, M.E.I.C., as director of technical services for the Institute.

J. H. Legere,
M.E.I.C.

Coming from Nova Scotia, Mr. Legere served five years with the Royal Canadian Corps of Signals. Demobilized in 1946, he enrolled at McGill University and in 1950 was awarded the degree of bachelor of engineering in engineering physics. Later he received a diploma in management and business administration from McGill.

Mr. Legere's industrial experience has been mainly in the fields of communications and electronic control. However, during the period 1954 to 1956 he was registrar of the Corporation of Professional Engineers of Quebec, and in 1955 he served as secretary treasurer of the Canadian Council of Professional Engineers.

More recently, Mr. Legere was chief engineer of Servomechanisms (Canada) Limited for two years, engaged in the design and manufacture of aircraft and industrial servomechanisms.

Periodicals in Engineering Libraries

The Engineering Journal has received confirmation of its importance as a source of reference in Canadian engineering and industrial circles.

In December 1958, the librarians of 75 leading Canadian engineering and industrial libraries were asked to complete a questionnaire, indicating which of sixteen periodicals they receive and retain. Sixty replies were received and tabulated.

Fifty librarians indicated that they keep *The Engineering Journal* on permanent file. The next highest technical publication was *Engineering News Record.* This was closely followed by *Engineering,* a British periodical.

The average retention figure for fifteen Canadian, British and American trade and technical periodicals was 24.6.

Bell Tower for U.B.C.

St. Andrews Hall at the University of British Columbia has a new 30-foot bell tower and bell, the gift of a New Westminster resident, Miss Annie Graham Hill, B.A., one of the university's earliest graduates.

The bell tower, built with funds donated by Miss Hill, commemorates her parents and step-mother. Her father, Arthur E. B. Hill, was a pioneer civil engineer, who helped to locate the C.P.R. Railway from Yale to Port Moody, and who helped to design and construct the first water supply system of New Westminster.

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 January 31, 1959.

Members: R. H. Abbott, Port Hope; R. M. Arner, Hamilton; D. L. Brignall, Hamilton; R. W. Gittins, Fort St. John; I. H. Lamb, Prescott; J. A. G. MacDonald, St. John's, Nfld; F. A. McCowan, Calgary; V. Milligan, Toronto; M. J. Morgan, Toronto; H. J. B. Nevitt, Sweden; R. J. Reeves, Hamilton; A. K. Rowntree, London; R. Sabljak, Vancouver; J. G. Spence, Kingston; R. H. Tanner, Belleville; N. Van Cleaf, Ottawa; A. L. Van Luven, Montreal.

Juniors: A. Alexander, St. Catharines; T. J. Gaffney, Sudbury.
Affiliates: H. D. C. Hunter, Victoria; C. G. Shaw, New Westminster.

Junior to Member: D. L. S. Bate, Toronto; E. W. Hill, Hamilton; J. C. Luscombe, Ottawa; J. I. McClelland, Trail; R. N. Payton, Hamilton; J. N. Schilizzi, Switzerland; K. D. H. Willcocks, Belleville.

Student to Member: J. M. Howes, Toronto.

STUDENTS ADMITTED

McGill University: E. Alzner, I. Alleslev, A. Amos, F. F. Angus, J. R. L. Atchison, P. E. Atkovitch, J. W. Atwood, J. O. Baatz, B. S. Basarke, J. D. Belcourt, D. L. Bercovitch, I. P. Bergeron, M. J. F. Bermingham, N. Berriman, C. H. Beuglet, R. L. Blackie, G. Bleier, G. D. Bonner, M. Boyer, R. Brousseau, M. L. M. Carle, I. A. Carson, R. C. H. Chen, W. B. Clarke, M. Cogan, A. J. Colman, E. G. Craig, W. Cupchik, N. Dion, G. A. Doig, M. Dorenfeld, J. R. Duckworth, P. A. Dupont, J. G. Dyke, R. D. Dyck, J. Egri, D. J. Ekanem, D. S. Elkins, F. H. Farmer, O. A. Fernandez-Cruz, G. R. Fitzbibbon, C. C. Flis, R. Fong, M. E. Fournier.
K. L. Fraser, Y. Freedman, A. J. Freyman, D. J. Galloway, S. B. Garfinkle, P. Gergely, F. M. Groundwater, L. Hamel, C. T. Harsora, E. C. Higgins, R. T. Holcomb, R. T. Horwood, D. U. Houghland, J. D. Hutchison, R. D. Japp, J. J. Kappel, P. R. Kemball, M. Kenney, M. Kiovsky, J. M. Klemka, H. P. Korman, L. Lahti, G. P. Laszlo, P. Lebeault, D. K. Lee, J. K. P. Lee, R. Y. M. Lee, R. Leibe, C. Loo, G. H. C. Lui, J. R. Mallamo, R. R. Martino, W. McCree.
D. W. McMullen, D. J. M. McVey, W. J. F. Meighan, C. Millar, L. Mincoff, G. N. Minns, P. J. Morrissette, T. N. T. Morse, R. H. Oldham, J. Opher, R. P. A. Pagotto, S. J. Polatshek, C. A. Potter, P. A. Preville, J. B. Quinlan, B. L. Rochester, A. D. Ross, C. A. Roy, D. J. Scholtz, D. G. Scott, L. Sebastien, D. T. Serbyn, H. T. Shrimpton, E. A. Silver, M. S. Sindhu, D. R. Smyth, L. Stein.
J. P. Stockhausen, T. D. Syme, R. G. Taylor, M. A. Tenander, R. B. Testa, N. Toye, J. M. Trischuk, T. Shang, S. R. Tumas, D. B. Uniat, R. H. Veach, D. A. Vivian, M. B. Walker, J. S. Watson, H. L. Wax, E. J. Weber, A. W. Y. Wong, T. F. Yung.

University of British Columbia: G. B. Allan, R. G. Auld, D. L. Birdsall, T. A. Bisaro, R. M. Boss, E. Bozgoz, D. W. Brown, D. A. Brundrett, A. F. Bygate, D. E. Chapman, H. R. Cherewick, A. T. Cooper, D. R. Crombie, G. D. Davidson, J. V. Davies, G. Doeksen, G. H. S. Duddy, R. A. Edgar, P. L. Eggleton, P. W. Elder, D. Erwin, G. A. Facca, D. L. Ferraro;
G. F. Fieber, D. M. Field, R. Gebauer, S. R. Greenwood, R. L. Hawkins, M. R. Higgins, R E. Higgins, T. J. Hirst, G. E. Hoar, W. H. Holland, H. Hooge, R. E. Horita, R. H. Hunt, H. Hussin, B. R. Isbister, G. A. Isbister, B. F. Jackson, N. A. Johnson, J. B. Kidston, W. L. Kilik, D. B. Kirk, A. V. Kouritzin, L. Kwan, V. S. Lamba;
M. Lambert, V. B. Lawson, O. H. Leiren, L. E. R. Lenoire, W. D. Little, E. J. Mazzuca, R. S. Moore, R. M. Murray, B. G. Mykvtiuk, D. W. Neilson, D. Nicholson, K. Oikawa, W. A. Olafson, W. V. Olson, M. H. W. Pau, T. P. Whittingham, E. J. Peterson, M. J. Polz, W. E. Reid, K. M. Richmond, L. A. Roosdahl, R. E. Rowlands, J. Saarma, R. V. Samol;
J. J. Sanderson, D. W. Saunders, E. H. Schroeder, R. G. Sexsmith, L. G. Shannon, H. A. Sharp, R. M. Sharp, J. Siiins, J. D. Smith, D. G. Strong, K. Teng, T. R. Tufts, R. M. Van Sacker, V. P. G. von Maydell, E. N. Walimaa, R. C. H. Werthner, T. M. White, P. A. Wiebe, A. W. Wild, L. F. Wolfe, P. Wong, W. D. Worobec, R. S. Zalkowitz.

University of Sherbrooke: J. Belleau, J. Bernier, P. Blais, Y. N. Boisselle, A. Breault, L. Chasse, R. Chasse, J. A. C. Cormier, M. Y. Demers, Y. Demers, D. Dumas, D. Gagnon, J. M. R. Gagnon, M. Labbe, P. Lacharite, P. Lambert;
L. Laplante, J. G. Lemay, J. R. M. Marcil, J. C. Moore, G. Morin, L. P. G. Morin, J. Morin, J. G. Nadeau, J. A. G. Richard, S. Richard, G. Teste, J. R. Tetreault, P. A. Tetrault, C. Tremblay, B. Vigneux.

University of Alberta: F. C. Astle, D. R. Ferrier, J. P. Ford, L. P. Haenni, A. Heidebrecht, R. L. Hemmings, M. P. Hermansen, W. F. Hobden, J. R. Hope, V. C. Jones, G. K. Leckie, D. A. Lindberg, P. Lukomskyi, D. G. Lunder, W. G. Maunder, R. B. Pinkney, P. T. Seabrook, K. J. Singleton, P. K. Symborski, T. H. Thomsen, E. I. Weleschuk, S. M. Zuk.

University of Toronto: R. T. Anthon, G. R. Bender, M. D. Davids, A. P. Fielden, D. K. Fountain, J. E. Garyfalakis, P. H. Griggs, B. M. Hersh, R. M. Korol.

University of Toronto: I. J. McGee, D. J. McLeish, R. J. Pau, R. Reio, A. A. M. Reed, V. Smiltnieks, D. R. Stemp, R. Taagepera.

McMaster University: I. C. Amery, P. I. C. Ernest, W. P. Gorrell, T. A. Hunter, R. E. Rowell, D. W. Weber.

St. Francis Xavier University: J. C. A. Beauchesne, P. Beauchesne, J. J. P. Bouvette, R. H. Burlock, J. R. Deschenes.

Queen's University: A. W. Armstrong, R. J. Balkwill, K. T. Bullen, A. G. Dyke, J. B. C. Roy.

Royal Military College: R. H. Brett, C. W. Dibden, M. J. Schelter, D. E. Woo.

University of New Brunswick: N. C. De Grace, G. A. Hatchard, R. J. Sharman, T. W. Walker.

University of Manitoba: F. P. Coinner, E. Romaniuk, R. T. Seepish.

Sir George Williams College: M. Chicha, I. Lindy, N. Vineberg.

Mount Allison University: T. A. Hiscock.

Waterloo College: H. S. Speers.

University of Saskatchewan: B. L. Vandall.

Nova Scotia Technical College: R. J. F. Swindles.

University of Alberta: K. C. Rainsberry.

Queen's University: E. R. Acton.

A.P.E.D.: J. A. Cummings.

Applications through Association

By virtue of the co-operative agreement between the Institute and the Associations of Professional Engineers, the following elections and transfers have become effective.

ALBERTA

Member: E. J. MacGinnis, J. D. Marshall; **Junior:** I. H. Barghshoon, J. D. Winkelaar, L. Davidson; **Junior to Member:** P. A. Clarke, F. C. Totino.

SASKATCHEWAN

Members: W. J. Keough, W. W. Petersmeyer, R. D. Lemmons; **Juniors:** V. K. Pedscalny; F. N. Trofimenkoff; **Junior to Member:** M. Barabas, B. K. Braaten, G. A. Gette, H. M. Hill, T. J. Manning, J. M. McNeil, V. L. Ryhorski, H. Solonginka, J. Stoffel, K. H. Thompson; **Student to Junior:** V. G. Beckie, A. C. Floyd, W. R. Hinz, W. E. Randall, A. G. Weimer, **Students:** A. W. D. Beck, D. V. Fowke, G. D. Genereux, D. L. Fraser, N. W. Ledray, J. W. McGuffin, W. F. Peterson, G. N. Steuart, M. G. Wilson.

QUEBEC

Member: I. W. G. MacCallum.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

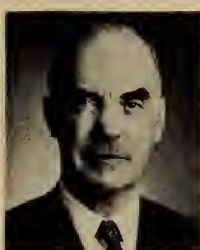
Dr. R. S. Jane, M.E.I.C., president of Shawinigan Chemicals Ltd. died on December 1, 1958.

Born in Cornwall, England, in 1898, Dr. Jane came to Canada in 1903. He graduated with a B.Sc. degree from the University of British Columbia in 1922. He was awarded an M.Sc. degree in chemistry in 1923 and a Ph.D. degree in 1925 by McGill University. He attended the University of London on a Wembley scholarship for the following two years. He received the degree of doctor of science from McGill University in 1958.

In 1927 Dr. Jane was named chief chemist at Shawinigan Falls, Que., with Canada Carbide Company. When that company became a division of Shawinigan Chemicals Ltd., he was placed in charge of plant research activities. In 1936 he was transferred to the research and development department in Montreal. In 1943 he was named director of the newly created industrial research department, Shawinigan Water and Power Company.

Three years later he returned to Shawinigan Chemicals Ltd., as director and vice-president in charge of research and development. He was appointed executive vice-president of the company in 1954, and president in 1956.


Dr. R. S. Jane, M.E.I.C.


J. W. McCammon, M.E.I.C.

He was elected president of the Chemical Institute of Canada for 1952-53.

J. W. McCammon, M.E.I.C., retired general manager and commissioner of the Quebec Hydro-Electric Commission, Montreal, died on December 4, 1958.

Mr. McCammon was born in Inverness, Que., in 1888. He attended McGill University, graduating with a B.Sc., degree in 1912, following which he served an engineering apprenticeship with the Canadian Westinghouse Company Limited, in Hamilton.

Between 1912 and 1929 he worked with Mackenzie Mann and Company in Montreal; as a manager of the hydraulic and electrical departments of the Canadian Fairbanks Morse Company, Montreal; and as contracting engineer and director, with the Charles Walmsley Company, Montreal. He joined the Beauharnois Light, Heat and Power Company in 1929 as assistant general manager. For nine years from 1934 he was a member of the Provincial Electricity Board and Quebec Public Service Board. It was in 1945 that he received the appointment to the newly created Quebec Hydro Electric Commission.

Mr. McCammon served with the Royal Canadian Garrison Artillery, the Seventh Canadian Siege Battery, and various British units, Royal Garrison Artillery, from 1916 to 1919.

Frank C. Tempest, M.E.I.C., who retired in 1956 as mechanical superintendent, Imperial Oil Company, Calgary, died on November 28, 1958.

He was born at Keighley, Yorkshire, England in 1891.

During World War I, he served as a dispatch rider for the 11th Canadian Field Ambulance, later transferring to the Royal Navy with commissioned rank. After the war he completed his education at the University of Alberta and late in 1922 he became draftsman for the Imperial Oil refinery, then under construction in Calgary. He was later promoted to engineer. About 1926 he was transferred to Royalite Oil Co., then a subsidiary of Imperial Oil Co., serving in Turner Valley as an engineer. In 1931 he was sent to the Tropical Oil Co., Columbia, S.A. where he served until 1938 as a refinery engineer. He rejoined the Imperial Oil Refinery at Calgary in 1940.

J. C. D. Taylor, M.E.I.C. of Winnipeg, Man., died on December 29, 1958.

Born in London, England in 1892, he attended Baltimore Polytechnic Institute, and studied civil engineering at the University of Philadelphia.

After working for a year with the Canadian National Railways, he joined the Manitoba Drainage Commission. Later he was municipal engineer for West Kildonan, Manitoba.

From 1924 to 1930 he served as superintendent with Canadian Engineering and Construction Company Limited. From 1935 until the outbreak of the second world war he worked on the design of the Winnipeg sewage treatment plant. During the war he was command engineer, No. 2 Air Command, R.C.A.F., on the design of water supplies and sewage disposal systems. In 1945 he was appointed hydraulic engineer of the City of Winnipeg.

In 1955 Mr. Taylor joined the firm of Haddin, Davis & Brown Limited, at Winnipeg.

Edward P. Innes, M.E.I.C., chief engineer, Canadian Canners Limited, Hamilton, Ont., died on August 22, 1958.

He was born at Simcoe, Ont., in 1910. He graduated from McGill University in 1934 with a B.Eng. degree in mechanical engineering. He joined Canadian Canners Ltd., taking charge of the engineering department. He was a director of Canners Machinery Ltd.

During World War II, he served with a technical liaison group at the British Ministry of Supply, London, and was promoted to major with the Canadian Army in 1944.

Marcel Guy Lanouette, M.E.I.C. died in July 1958.

Born in Montreal on September 13, 1913, he attended Ecole Polytechnique where he graduated with a B.A.Sc. (C.E.) degree in 1941.

From 1941 to 1945 he worked with the Canadian Broadcasting Corporation.

He joined the Lower St. Lawrence Power Company in 1945, where he was distribution engineer.

He was vice-chairman of the Lower St. Lawrence Branch of the Institute.

William James Edington, M.E.I.C., retired city engineer for the City of Moncton, N.B., died on September 25, 1958.

He was born on March 10, 1889 at Moncton. Graduating in civil engineering from the University of New Brunswick in 1919, he joined the city engineering staff. He became city engineer in 1948.


W. J. Edington, M.E.I.C.

In 1954 he retired from the post, but was retained by the city in an advisory capacity. He was engaged on a special engineering assignment at the time of his death. His service to Moncton spanned 39 years.

He served in the Canadian Expeditionary Force in the first world war.

M. J. Stanbridge, JR.E.I.C., of Winnipeg, was the victim of a traffic accident in the summer of 1958.

Born in Winnipeg, Manitoba in 1934, he attended Daniel McIntyre Collegiate and the University of Manitoba, where he was awarded his B.Sc., (Geol.) degree in 1956.

Personals

J. E. Sears, M.E.I.C. (civil, Queen's 1910) has retired from his practice as an Ontario Land Surveyor in the Huntsville area, Ontario.

H. Graham, M.E.I.C. (electrical, Bradford, England 1925) chief engineer, Public Utilities Commission, Victoria, B.C., has been elected chairman of the Vancouver Island Branch of the Institute.


H. Graham, M.E.I.C.


H. E. Seely, M.E.I.C.

J. E. Harrington, M.E.I.C., president of Anglin-Norcross Corporation Ltd., was elected president of the Canadian Construction Association for 1959.


W. J. Horner, M.E.I.C.


J. E. Harrington, M.E.I.C.

W. J. Horner, M.E.I.C. (B.Eng., mech., Saskatchewan, 1945) is chairman for the Kitchener Branch of the Engineering Institute for 1959. Mr. Horner is sales engineer with Sheldons Engineering Ltd., Galt, Ont.


E. Mason, M.E.I.C.


W. G. Small, M.E.I.C.


G. M. Young, M.E.I.C.


E. T. Harbert, M.E.I.C.

W. D. Barron, M.E.I.C., (B.Sc., mining, Queen's, 1943) has been appointed branch manager for the Province of Quebec, by T. McAvity & Sons Limited, Saint John, N.B.

Gilbert M. Young, M.E.I.C. (B.Eng., mech., McGill, 1934) has recently been appointed vice-president and general manager, Canadian Ingersoll-Rand Company Limited, Montreal.

E. T. Harbert, M.E.I.C. (B.Sc., mech., McGill 1923) formerly manager of engineering, Canadian Ingersoll-Rand Company Limited, Sherbrooke, Que., has been appointed works manager for the company.

W. A. Osbourne, M.E.I.C., (B.A.Sc., Toronto 1924) has retired as president of Babcock-Wilcox and Goldie-McCulloch Limited, He has been elected vice-chairman of the board of directors.

Ernest Mason, M.E.I.C. (Manchester Coll. Tech., 1922) chief design engineer of the Consolidated Mining and Smelting Company of Canada Limited, Trail, B.C., became a consulting engineer of the company on January 1.

Lloyd Williams, M.E.I.C. (B.A.Sc., elec., British Columbia, 1932) has been named assistant to the manager of the engineering division, Consolidated Mining and Smelting Company Limited, Trail, B.C.

W. G. Small, M.E.I.C. (B.Sc., civil, Saskatchewan, 1924) has been named chief instrument engineer, Consolidated Mining and Smelting Compay, Trail, B.C.

Hugh E. Seely, M.E.I.C., of Robertson-Irwin Limited, formerly of Hamilton, has been appointed manager of the Toronto district sales for the company.

P. E. Savage, M.E.I.C., has been appointed regional vice-president of the eastern region of the Dominion Bridge Company, Limited, in a reorganization of the Company creating four new regions. Each region will be controlled by a regional vice-president operating from the Montreal head office.

Mackenzie McMurray, M.E.I.C., is the new vice-president for the Ontario Region of Dominion Bridge Company, Limited.

E. A. Ford, M.E.I.C., has been named vice-president of the central region of the Dominion Bridge Company, Limited.

R. J. A. Fricker, M.E.I.C., will be regional vice-president of the western region of Dominion Bridge Company, Limited.

Robert S. Eadie, M.E.I.C., has been appointed vice-president and director of engineering, Dominion Bridge Company, Limited.


W. A. Osbourne, M.E.I.C.


W. D. Barron. M.E.I.C.

George H. Midgley, M.E.I.C., has been named vice-president and manager of the new marketing services group, Dominion Bridge Company, Limited.


G. H. Midgley, M.E.I.C.


P. E. Savage. M.E.I.C.


M. McMurray, M.E.I.C.


R. J. H. Fricker. M.E.I.C.


R. S. Eadie, M.E.I.C.


E. A. Ford. M.E.I.C.

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It's a daily encounter, as Kent Strang, a welding operator at our Toronto plant gets down to work with the highly efficient and versatile Pandjiris automatic welding manipulator, a portion of which is seen in operation above.

Both Strang and Pandjiris are "tops" in their respective fields — for in Toronto, as in 13 other Dominion Bridge plants from coast-to-coast, skilled operators work with up-to-date equipment of many types in the production of high quality platework for almost every Canadian industry.

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Platework by DOMINION BRIDGE

• PERSONALS


J. M. Reid, M.E.I.C.


G. Eriksen, M.E.I.C.


D. R. Brown, M.E.I.C.

D. R. Brown, M.E.I.C. (B.Eng., mech., 1944; M.Eng., 1951, McGill) has been transferred to Monsanto Chemical Company, Dayton, Ohio, as a mechanical engineer in the research department, research and engineering division.

J. R. Burgess, M.E.I.C. (B.A.Sc., mech., Toronto, 1910) recently retired from the position of mechanical superintendent of Canadian Wallpaper Manufacturers Ltd., Leaside, Ont. He has since been engaged as a clerk of works for Marani and Morris on a project at London, Ont.

James M. Reid, M.E.I.C. (B.A.Sc., elec., British Columbia, 1951) has become district sales manager of the Pirelli Cables, Conduits Limited new sales office in Vancouver.

J. W. Demcoe, M.E.I.C. (B.Sc., civil, Manitoba 1939) is general superintendent of the Southern Ontario District, Canadian National Railways, with headquarters in Toronto.

J. H. Jackson, M.E.I.C. (B.A.Sc., civil, Toronto, 1947) is construction manager at Otter Rapids, Ont., for the Hydro Electric Power Commission of Ontario.

A. P. Wiles, M.E.I.C. (B.Sc., engrg. phys., Saskatchewan, 1946) has joined the defense systems division, of RCA-Victor Company Ltd., Montreal as systems engineer.

G. Eriksen, M.E.I.C. (civil, Oslo, 1925) is an engineer with the Ontario Water Resources Commission, Toronto.

B. Baribeau, M.E.I.C. (B.A.Sc., civil, Montreal, 1943) who was in Paris, France, as manager of European operations for Defence Construction (1951) Limited, has been transferred to Ottawa.

G. L. Wilson, M.E.I.C. (B.A.Sc., civil, Toronto, 1951) is deputy township engineer of the township of Etobicoke in Metropolitan Toronto.

E. R. Quinn, M.E.I.C. (B.Sc., mech., Queen's 1951) has joined Irving Pulp & Paper Ltd., Lancaster, N.B. as maintenance engineer.

John L. Kearns, M.E.I.C. (B.A.Sc., chem., Toronto 1945; Ph.D., Iowa State College, 1954) is associate professor of engineering science at the University of Western Ontario, London.

Wm C. McLean, M.E.I.C. (H.N.C., mech., Glasgow Royal Technical College, 1946) of Sarnia, Ont. has joined the Canadian Chemical Company, Edmonton, Alta., as maintenance engineer.

G. N. Hutchinson, M.E.I.C. (B.Sc., elec., Queen's, 1949) of Fort William, Ont., is now a maintenance supervisor with the Universal Cyclops Steel Corporation in Coshocton, Ohio.

O. Graham, M.E.I.C. (C.E., civil, Ecole Polytechnique 1921) is engineer superintendent with Desourdy Construction Limited, Ville Jacques Cartier, Que.

F. A. Lazenby, M.E.I.C. (B.A.Sc., civil, British Columbia, 1925) was recently appointed assistant chief engineer (executive) of B.C. Electric.

S. L. Kenez, M.E.I.C. (civil and general, Nador, Hungary, 1942) has joined the

City of Hamilton engineering department as roadway engineer.

K. H. Bjerring, M.E.I.C. (B.Sc., elec., Manitoba, 1934) has recently joined the staff of Stevenson & Associates, architects and engineers, Calgary, as a mechanical engineer.

H. W. Nasmith, JR.E.I.C., (B.A.Sc., British Columbia 1950; M.A., Washington University 1951) has joined the consulting engineering firm of R. C. Thurber & Associates Ltd. of Victoria, B.C.

Donald W. Rae, JR.E.I.C., (B.Eng., civil, McGill, 1956) has been named contract sales engineer for Horton Steel Works Limited in Montreal.

W. R. Lymburner, JR.E.I.C., (B.Sc., civil, Alberta, 1950) is a project engineer for Willis & Cunliffe Engineering, Victoria, B.C.

D. R. Gilham, JR.E.I.C.

W. R. Lymburner, JR.E.I.C.

G. T. Trotter, JR.E.I.C.

J. F. Preston, JR.E.I.C., (B.Eng., McGill 1950) resident engineer for the Du Pont Company of Canada (1956) Limited Maitland projects, has been transferred to the company's Sarnia projects.

G. T. Trotter, JR.E.I.C., (H.N.C.E., civil, London, England, 1957) has accepted a position as designer with Dominion Bridge Company Limited, at Winnipeg.

D. R. Gilham, JR.E.I.C., (civil, Portsmouth, England, 1955) is subdivision engineer in the township of North York, Ont. He was previously with the City of Hamilton.

J. Renchko, JR.E.I.C.

F. P. Linares, JR.E.I.C.

J. F. Preston, JR.E.I.C.

Francisco de P. Linares, JR.E.I.C., (mech., Barcelona, Spain, 1956) is presently with Massey-Ferguson Ltd., Toronto as industrial export sales manager.

J. Renchko, JR.E.I.C., (B.Sc., elec., Saskatchewan 1949) has accepted a position with Massena Electric Company, Massena, N.Y., as electrical engineer.

R. P. Baronet, JR.E.I.C., (B.Eng., mech., McGill, 1950) has become sales engineer at Peacock Brothers Ltd., Montreal.

• PERSONALS

J. Favron, JR.E.I.C., (B.Sc., mechanical and electrical, Ecole Polytechnique 1952) has accepted a post as air systems designer with Grumman Aircraft Engineering Corporation, New York.

F. E. MacIntyre, JR.E.I.C., (B.Sc., mech., Queen's 1949) is teaching at Glebe Collegiate Institute, Ottawa, as mathematics teacher.

R. G. T. Wilson, JR.E.I.C., (H.N.C., elec., Birmingham, England 1955) has joined the Foundation Company of Canada Ltd., as electrical engineer, on the Inco project at Thompson, Manitoba.

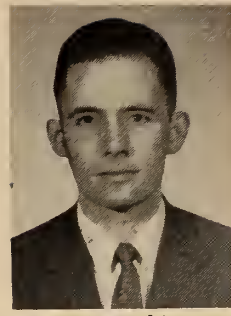
W. R. Coles, JR.E.I.C., (B.Eng., civil, McGill 1951) is in Geneva, Switzerland, attending the Centre d'Etudes Industrielles.

G. R. Begley, JR.E.I.C., (B.Eng., elec., McGill 1956) project officer for National Scientific Laboratories for ground controlled approach radar installations of the R.C.A.F., transferred in October 1958 to H.F. communications installations, employed by the Canadian government.

S. B. Smith, JR.E.I.C., (B.Eng., mech., McGill 1949; Eng.Sc.D., management engineering, Columbia 1958) is the manager of business policy and methods research, semiconductor division, for the Raytheon Manufacturing Company, Boston, Mass.

J. H. Westaway, JR.E.I.C.

S. B. Smith, JR.E.I.C.



A. M. White, JR.E.I.C.

S. G. Bruskiewich, JR.E.I.C., (B.Sc., mech., Saskatchewan, 1956) technical officer in the Royal Canadian Air Force has been transferred from France to headquarters in Ottawa.

A. M. White, JR.E.I.C., (B.A.Sc., mech., British Columbia 1949) has accepted a position with the Kaohsuiung Ammonium Sulfate Corporation Ltd., in Taiwan, China.

R. A. Plouffe, JR.E.I.C., (B.A.Sc.,) mech. and electrical, Ecole Polytechnique, 1951) of the Quebec branch of Canadian Westinghouse Company Limited, has been transferred to the company's Montreal office as manager, Agency and Resale, Eastern District.

A. H. Ruel, JR.E.I.C., (B.Sc., civil, Ecole Polytechnique, 1953) is now resident engineer for Beauchemin, Beaton & Lapointe, consulting engineers, Montreal.

W. C. Moffatt, JR.E.I.C., (M.Sc., mech., Queen's 1958) is at Massachusetts Institute of Technology to do post-graduate work in mechanical engineering.

J. H. Westaway, JR.E.I.C., (B.Sc., mech., Queen's 1952) former project engineer with Potash Company of America Ltd., Saskatoon has joined Dustbane Manufacturing Co. Ltd., Ottawa as manager, machine division.

C. V. MacLachlan, JR.E.I.C., (B.Eng., elec., McGill, 1950) is manager of the Public Utilities Commission at Ingersoll, Ont.

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations.

PRINCE EDWARD ISLAND

Officers Elected

The Association of Professional Engineers of Prince Edward Island announce new officers, as follows: president, L. A. Coles, Summerside; vice-president, R. D. Donnelly, Charlottetown; past president, C. W. Currie, Charlottetown; councillors, A. D. Cameron, J. L. Boomhower, C. H. Stewart, and W. S. Veale, all of Charlottetown.

QUEBEC

Engineering Activity in Quebec

Guillaume Piette, president of the Corporation of Professional Engineers of Quebec made some observations about engineering recently.

We can anticipate, he said, that in five year's time Quebec universities may graduate 1,000 new engineers per year as a result of the construction, by the provincial government, of the new Ecole Polytechnique, the establishment of a new School of Engineering at Sherbrooke and major additions to existing engineering faculties now underway or in the planning stages.

Mr. Piette said that in Quebec, more and more young men are turning to engineering careers, as witnessed by the tremendous increase in the enrolment since the end of the war.

The Corporation, he said, had undertaken an informal survey to determine the number and value of major engineering construction projects ($1,000,000 or more) undertaken, underway or completed in Quebec.

The survey uncovered some 150 such projects representing a total value of more than 2 billion dollars. Of these, roughly half, valued at one billion dollars, were in the Montreal area alone.

"This is far from being the complete picture," Mr. Piette emphasized. The figures represented only part of the engineering projects being worked on in 1958. There are probably many other projects of $1,000,000 or more. Moreover the sum of all smaller engineering projects might raise the total figure to well over $3 billion.

"And, of course, we have not taken into account the equally important but more difficult to measure achievements that are taking place in the fields of manufacture and production", he stated. "It is evident from the picture of the province's development in all fields of engineering during 1958 that most of our engineer members were very busy indeed".

ONTARIO

Annual Meeting, January

Speaking at the annual meeting of the Association, January 24, Col. T. M. Medland, executive director, stressed the need for an atmosphere "in which our engineers may grow professionally by providing technicans and clerical assistance that will enable the engineer to have time to think and to create". There was also room, he said, for increasing the awareness of professional attitude among the profession.

It is for every professional engineer who moves into management to remember that he still owes an allegiance and obligation to his profession and its members, and it is for the younger engineer to display a trust and confidence in those for whom he works," he stated.

BRITISH COLUMBIA

Councillors appointed

B.C. Government appointments to the council of the Association have been made since the annual meeting in December. These councillors are: C. B. Archibald, P.Eng., F. A. MacLean, P.Eng., O. Safir, P.Eng., and M. A. Thomas, P.Eng.

"Forward March"

Abstract of an editorial by President R. E. Wilkins, from "The B.C. Professional Engineer", January, 1959.

Last year we all recognized as being one of economic consolidation, and rightly so. This year there are many signs which indicate we must ensure that our professional development is such that we will be able to contribute our best to this inevitable and tremendous growth of our province.

During the past ten years the number of registered engineers within British Columbia has increased by 100 per cent. We now have 2,200 registered engineers and the potential addition, within two years, of another 700 who are now employed as engineers-in-training within the province.

A large number of these engineers will be participating as key men in the economic development of British Columbia and they can have a tremendous influence for good, perhaps a greater influence than any other segment of the community.

With this growth in our numbers and our influence, we must not lose sight of the fact that while our certificate of registration entitles us to certain rights and privileges it also imposes upon us very definite obligations and responsibilities. The extent to which our right to practice is respected by others depends both upon the deportment of the individual and the collective actions of our Association. We must strive continuously for a higher standard of individual competence, and greater stature and dignity for the Association.

Prior to 1949, the work of the Association was largely done by a comparatively small number of engineers who selflessly dedicated a large part of their time to developing the firm foundations upon which we have since built. We owe these engineers a great debt of gratitude.

Since 1949 there has been an ever increasing number of engineers who, by service in an expanding number of committees of the Association, have made many significant contributions. Thus, it is not necessary for a member to be elected or appointed to Council to be of service to the Association. At best, Council can serve as a registration body and formulate and execute action on matters of major policy. There is a vast amount of other work to be done by committees and individuals.

Each member of the Association has an obligation to share in the work of the Association and to contribute personally toward the enhancement of the practice of professional engineering within and without the province.

We have the organization; we have the strength; let us all march forward in unity and strive for a greater quality and pride in our profession.

NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute and abstracts of the papers presented at their meetings

BELLEVILLE

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

JOHN G. TODDS, manager, operations research, Northern Electric Co. Ltd., Montreal, addressed the branch on February 9.

Operations research originated with the military during World War II, and was adapted to industry in the early '50's. Management problems can be solved mathematically by using models fitted to raw data and manipulating relatively common formulae to fit the problem within specified limits.

BROCKVILLE

J. R. Eastwood, M.E.I.C., *Correspondent*

DR. KENNETH F. TUPPER, president of the E.I.C., was guest of honour at a meeting of January 21. The members enenjoyed hearing his reminiscences of a recent trip to Russia.

CAPE BRETON

H. M. Aspinall, M.E.I.C., *Correspondent*

THE ANNUAL BUSINESS MEETING took place on December 10, 1958, in Sydney.

Elections resulted in the following slate of officers: Chairman, W. L. Dodson; vice-chair., C. A. Campbell; secretary, H. M. Aspinall; treasurer, H. C. Maitland; executive members, R. Bradley, L. Boutillier, J. Laffin, R. Bezanson, P. Terry and J. Stevens.

This meeting also considered the setting-up of a scholarship fund for the benefit of engineering students in the area.

Activities for 1958 closed with a New Year's Eve party for members, wives and friends.

FREDERICTON

Lyle W. Smith, JR.E.I.C., *Correspondent*

DONALD SLACK, engineer, maintenance of way, Canadian National Railways, Atlantic Region, spoke at the meeting of January 19, 1959. He described the C.N.R. hump yard at Moncton, the initial cost of which will be $17 million. Great savings in operating costs will be effected by this installation, and speedier delivery of goods will result from ease of handling large volumes of traffic.

HAMILTON

J. R. Currie, M.E.I.C., *Correspondent*

CANADA'S AIRWAYS OF THE FUTURE were illustrated by Harold J. Connolly for members of the Branch attending a meeting of January 15. Mr. Connolly is director of the construction branch, Department of Transport, Ottawa.

Following a reception and dinner, the Branch reports for 1958 were given, and the installation of new officers took place. The officers: H. G. Seely, chairman; R. G. Stevenson, vice-chairman; J. R. Harbell, secretary; new executive members, P. J. McNally, M. M. Kennedy, H. K. Crean, and W. J. Hohn.

MONTREAL

K. L. Pinder, M.E.I.C., *Correspondent*

THE TECHNOLOGY OF WINE was considered by the Chemical Section at a meeting of December 3, 1958, with the help of guest speaker A. deChounac, director of research T. G. Bright & Co. Ltd., Niagara Falls, Ont.

Wine making being the first chemical engineering process, it merits historical study, Mr. deChounac believes. He described the making of Canadian wines, demonstrating with samples of Canadian champagne, and illustrating with a movie.

NIPISSING AND UPPER OTTAWA

D. J. Thornton, S.E.I.C., *Correspondent*

LOW TEMPERATURE Properties of Lubricants and Hydraulic Fluids was the subject of a talk given by A. G. "Bert" Almack, industrial sales manager of Imperial Oil Limited, Toronto, at a meeting of the Branch on December 9, 1958.

He covered: temperature vs. viscosity; hydraulic fluids, engine crankcase oils and automotive gear lubricants, and took part in an interesting discussion.

PETERBOROUGH

J. G. Hooper, M.E.I.C., *Correspondent*

PRESIDENT K. F. TUPPER, and Mrs. Tupper, Dr. Garnet Page and Mrs. Page visited Peterborough on January 15.

Highlights of the visit were: an afternoon branch executive meeting with the president; evening stag dinner for 65, Dr. Tupper giving his impressions of the Soviet Union and Dr. Page showing slides of their recent trip to Russia. In addition there was a cocktail hour and buffet supper for Mrs. Tupper, Mrs. Page and Mrs. Robertson, arranged by the Women's Auxiliary.

SARNIA

C. M. Stewart, JR.E.I.C., *Correspondent*

SARNIA engineers had the opportunity of hearing Dr. Kenneth F. Tupper, E.I.C. president, speak about Russia's strides towards industrialization, on November 25. Dr. Tupper spoke of possible reciprocal visits of Russian and Canadian engineers and scientists.

The visit of Dr. Tupper and General Secretary Garnet Page was made the occasion of a dinner dance, attended by some 100 members and their wives.

SUDBURY

F. Jackson, M.E.I.C., *Correspondent.*

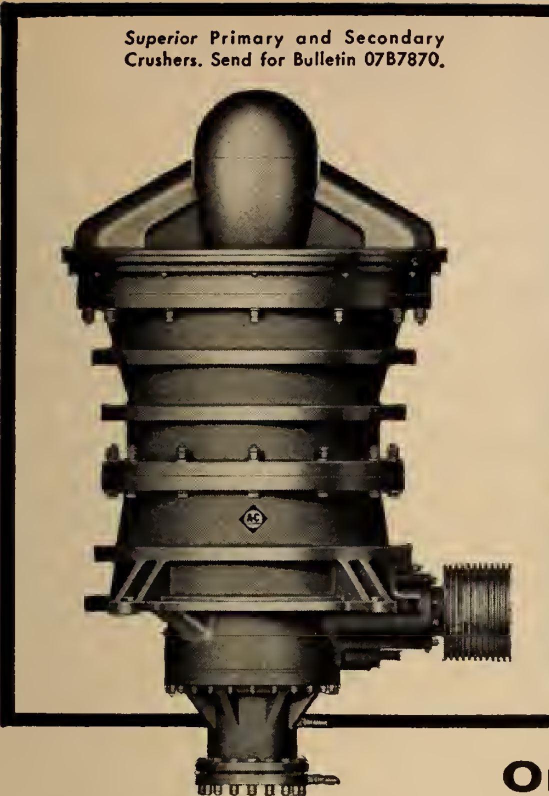
HYDRAULICS IN INDUSTRY was the subject discussed by C. F. Smith, manager, manufacturing division, Vickers, Sperry Ltd., at a branch meeting of February 12, 1959.

THE FIRST CENTRAL ONTARIO REGIONAL TECHNICAL CONFERENCE was announced by George Charlap, who is chairman of the organizing committee. The general theme is to be Engineering Outlook in Canada in the Next Twenty Years.

GRAHAM P. KEMP, M.E.I.C., sales engineer of Worthington Canada Ltd., talked to the members at a meeting of January 15 on Design and Selection of Pumps for Various Service. He had some advice for customers selecting pumps, and he answered questions after his address.

REGINA SECTION

THE WINTER FROLIC was held Friday evening, November 28, in the Shrine Temple ballroom. Jim Crate, social chairman of the Regina section was in charge of arrangements for the social season highlight. Ralph Cook, a member of the social committee, was master of ceremonies. Mrs. L. T. Holmes, social chairman of the Professional Engineer Wives, and her committee were in charge of decorations.



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Only Allis-Chalmers gyratory crushers have exclusive

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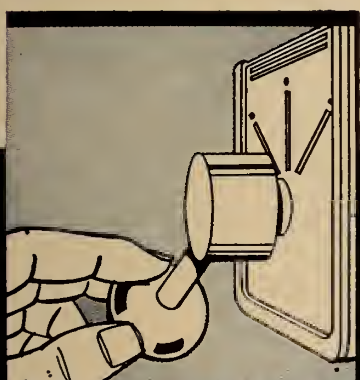
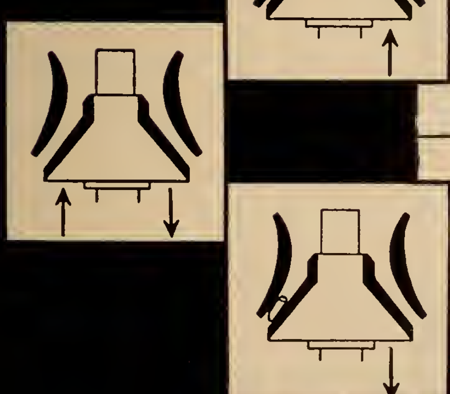


HUNDREDS of crushing operators around the world have improved their plant efficiency and tonnage with Allis-Chalmers gyratory crushers equipped with *Hydroset* mechanism. This remarkable design feature has provided economy and convenience in crushing a wide range of materials — from andesite to zinc ore, and including the crushing of taconite in the world's largest crusher. No other gyratory crusher even approaches the time-saving advantages of "one-man, one-minute" product control offered by Allis-Chalmers crushers equipped with *Hydroset* mechanism.

"One-Man, One-Minute" product control

Hydroset mechanism raises or lowers the mainshaft hydraulically in less than a minute — at the flip of a switch.



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Annual awards for engineering achievement were presented to Lloyd T. Holmes, deputy minister, Saskatchewan Department of Highways, Ken R. Pattison, city engineer, City of Regina and Karl W. Allcock, operating superintendent of the Saskatchewan Power Corporation.

TORONTO

Gordon F. R. Norton, JR. E.I.C., *Correspondent*

PAUL H. MILLS, Q.C., spoke at the meeting of November 20, on the subject of "Some Observations on Engineering Contracts."

Mr. Mills outlined two recent court cases, concerning construction contracts.

The speaker reflected for a short time, on his recent trip to Greece, and suggested that engineers who were retired, could find good use for their talent in assisting under-developed countries through the Colombo Plan.

The Branch welcomed as guests to this meeting the members of the A.I.E.E., Toronto Section.

THE ANNUAL MEETING of the branch took place on January 15, with 32 members and guests attending. Chairman Harvey Self moved the business along at a lively pace.

F. G. Gardiner, Toronto's super mayor, was the guest speaker, his timely subject: Suburbia Explodes.

STUDENTS NIGHT was held in Hart House on January 29, A. C. Davidson chaired the meeting which was arranged as a quiz contest. W. Larri was the moderator; the judges were E. Potter, M. J. Simpson, and M. Kitchen; timekeepers, G. Bonham, and R. Shaeff. In the final analysis the Mining engineers won out, with Engineering Business a close second, followed by the Mechanical boys.

VANCOUVER

J. J. Kaller, M.E.I.C., *Correspondent*

AT A NOVEMBER 19 MEETING organized by the Structural Section R. Clough, M.E.I.C., presented a lecture on Welding Failures. Mr. Clough used various examples of failure of welded construction to bring out many points necessary for the sound design of simple and complex welded structures.

ON NOVEMBER 26 branch members made a tour of the facilities of the B.C. Telephone Company, with particular emphasis on the B.C. portion of the trans-Canada micro wave system.

AT THE DECEMBER 3 MEETING, Peter Schearer, a Swiss engineer, working on a snow slide and avalanche problem at Glacier, B.C., gave a talk on Avalanche Observation and Control. The subject proved interesting to B.C. engineers, who sometimes have to contend with similar conditions. The Soils Group collaborated in this meeting.

OTTAWA

A. H. Graves, JR.E.I.C., *Correspondent*

W. L. KEAY, engineer in charge of sewage and drainage branch, Planning and Works Dept., City of Ottawa, discussed proposed new sewage disposal plant to be constructed at an estimated cost of $8,650,000. Approximately 70 persons attended, on December 4, 1958.

CENTRAL BRITISH COLUMBIA

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

LES McLEAN spoke at a meeting on January 30, on the subject The Expanding Universe, The Amazing Universe. Interest was shown in Mr. McLean's subject by the many questions asked.

CHALK RIVER

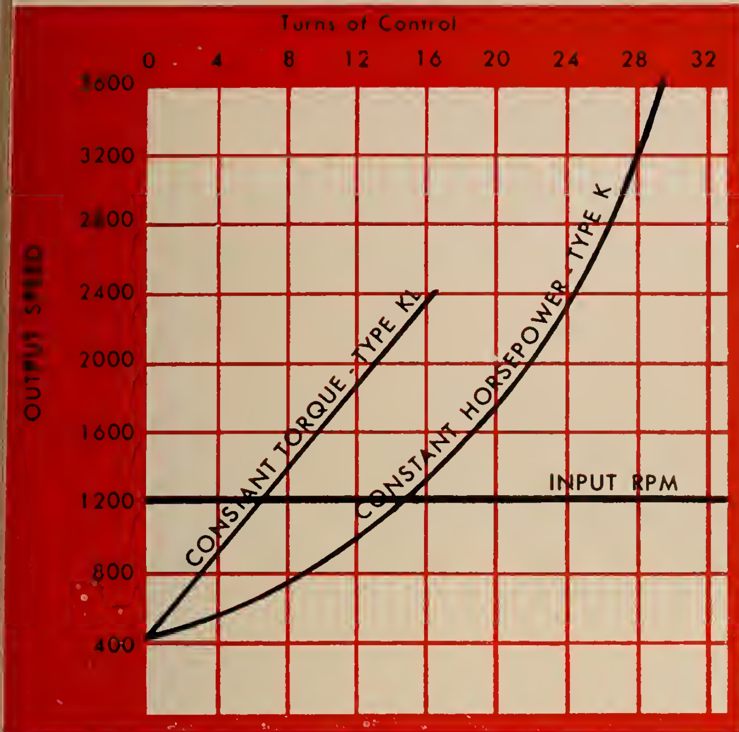
C. A. Crawford, JR.E.I.C., *Correspondent*

OUR MR. SUN, the excellent film provided by the The Bell Telephone Company, was shown at a regular meeting of the Branch on December 17.

FREDERICTON

Lyle W. Smith, JR.E.I.C., *Correspondent*

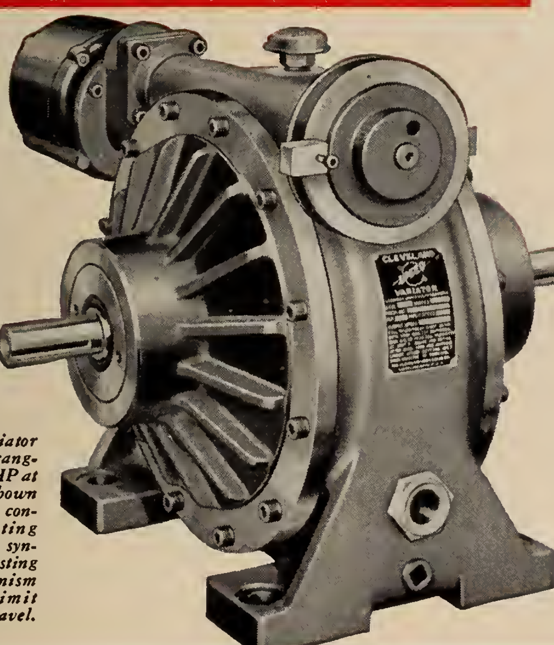
THE POLICY OF POLLUTION CONTROL and its effects on N.B. industry and citizens was the subject of a panel discussion at



CLEVELAND SPEED VARIATOR

Accurately Provides Dependable, Infinitely Variable Speed Control

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.

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.

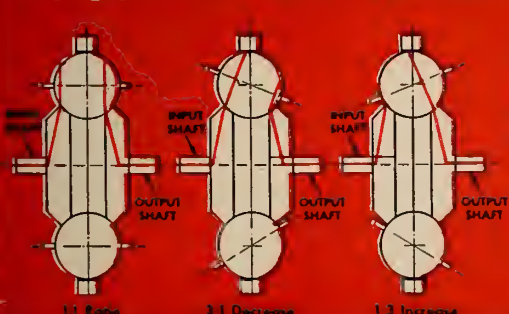
Infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range—from ⅓ to 3 times input speed. Output speed can be adjusted by either a hand wheel on the Variator or by manual or automatic remote control.

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.

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).

"It's the Drive That's on the Ball."

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SYDNEY • TORONTO • SUDBURY • WINNIPEG • EDMONTON • CALGARY • VANCOUVER a meeting on December 15. The speakers were Dr. Bates, of the N.B. Water Authority, Alwin Cameron, provincial sanitary engineer, and Ronald Bemrose, superintendent of Oromocto sewage disposal plant.

The N.B. government has legislation covering waste disposal into rivers and coastal waters, Mr. Bates reported. New Brunswick can avoid the serious trouble encountered by other highly industrialized areas, Mr. Cameron said. Atomic pollution, in particular, would affect such important N.B. resources as fishing and the tourist industry.

Mr. Bemrose explained the operation of the Oromocto sewage treatment plant, which helps to prevent overpollution of the St. John river.

HALIFAX

W. J. Phillips, M.E.I.C., *Correspondent*

The annual meeting of the branch was held December 15, 1958. The following officers were elected: chairman, W. J. Phillips, vice-chair., H. A. Marshall, sec.-treas., J. E. Reardon; executive, J. G. Belliveau, J. R. Cameron, K. R. Mitchell, G. MacD. Haliburton, B. E. Langley, R. B. Webber, G. F. West, H. L. Archibald, C. I. Cameron, H. W. Doane

LAKEHEAD

R. L. Wimperis, JR.E.I.C., *Correspondent*

The annual meeting of the Branch was held on December 12. Reports from the chairman and the committees on finance, papers, entertainment and membership showed a successful year, with good attendance at meetings.

Elections resulted in the following list of officers: chairman, L. F. Mason-Tulby; vice-chair., N. Paoline; sec.-treas., R. L. Wimperis; executive, W. Hogg, W. B. Sproule, O. Dodson, K. R. Johns.

LAKEHEAD

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

T. C. Keefer, field secretary of the Association of Professional Engineers of Ontario was the speaker on February 9. His subject was the salary survey conducted in Ontario and Quebec. The salary survey will help to promote the professional status of engineers, removing one barrier in the employer-employee relationship.

D. B. McKillop gave a report of a meeting of Council of the E.I.C. in January. Mr. McKillop's belief was that Confederation could be accomplished within the next eighteen months. This was welcome news to the Branch. J. Ryhmes gave a brief report of a meeting of council of the A.P.E.O. which he had attended.

LETHBRIDGE

G. G. Campbell, M.E.I.C., *Correspondent*

A. E. Palmer, discussed Construction Methods in West Pakistan at a meeting of January 17, 1959. He has spent two years in Pakistan on a Colombo Plan appointment.

In construction of dams, roads, irrigation works and buildings, manual labour is used wherever possible, to relieve the 50 per cent unemployment figure.

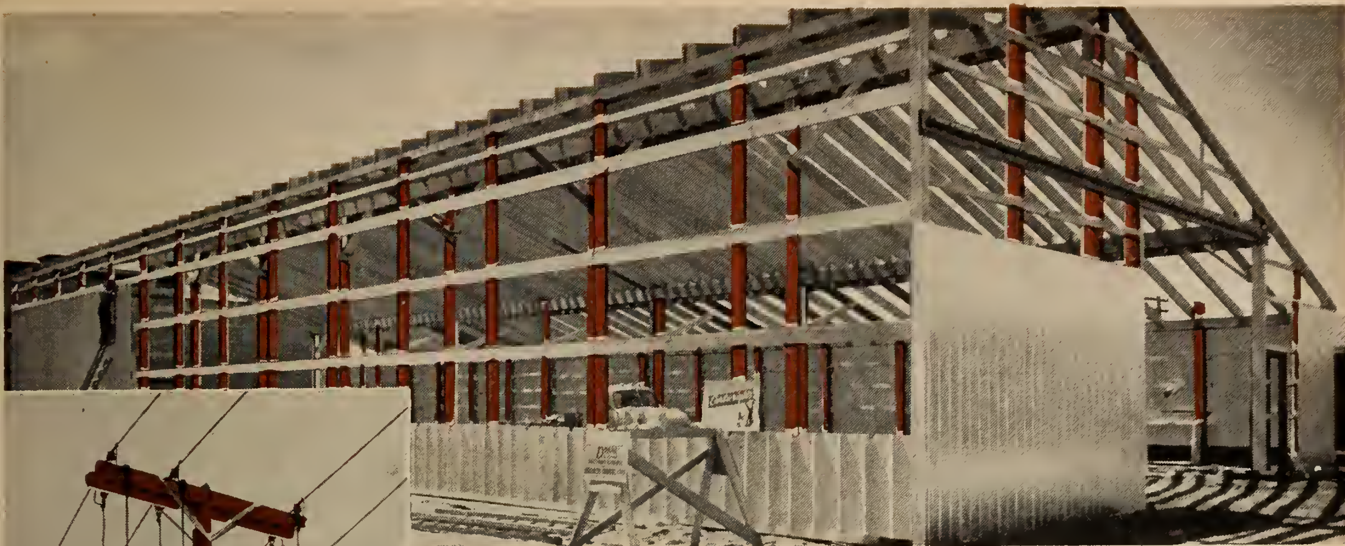
Remarkable progress has been made in Pakistan to improve agricultural and industrial output. Paper and textiles have become, in a very short time, items produced there and exported. The main purpose of increasing exports is to enable Pakistan to buy food from other countries.

PETERBOROUGH

J. G. Hooper, M.E.I.C., *Correspondent*

The branch entertained the general secretary Dr. Garnet Page and Mrs. Page on December 10, 1958. While Dr. Page met with the members, Mrs. Page was entertained by the ladies' Auxiliary.

Dr. Page reviewed the work of the E.I.C., its purposes and objectives. Dr. Page also gave an interesting commentary to his film coverage of his



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DIVISION OF DOMINION TAR & CHEMICAL COMPANY, LIMITED recent visit to the U.S.S.R.

Refreshments were served at the home of Mrs. Hubert Sills, und.r the auspices of the Ladies' Auxiliary.

VANCOUVER ISLAND

H. F. Coupe, M.E.I.C., *Correspondent*

FLOOD CONTROL AND HYDRO ELECTRIC POWER IN THE FRASER RIVER was the subject of a panel discussion at a meeting on January 21, 1959. Moderator was: A. F. Paget, M.E.I.C., provincial water comptroller; panel members were: G. S. Andrews, T. A. J. Leach, and G. E. Simmonds.

The history of the Fraser River board was outlined. There was also discussion of surveying methods, hydrology of the watershed and flood control and power development schemes, which form parts of the recently completed Fraser River Board project.

CALGARY

Neil Carr, M.E.I.C., *Correspondent*

FISH AND POWER ON THE RIVERS OF B.C. was one subject discussed at a meeting of January 22, by the Hon. James Sinclair, president, Fisheries Association of B.C. W. F. McMullen, personnel manager, Canadian General Electric Co., Toronto, Ont., spoke on the subject of Changes in Engineering Utilization.

Mr. Sinclair spoke against damming the Fraser river. The combined potential of the Peace and Columbia rivers will provide adequate power for 20 years, in his opinion. The $80-million fishing industry could be doubled in the next 50 years, if the river is not developed for power, he said.

The role of the engineer is changing, Mr. McMullen said, now that he is beginning to have the aid of technicians, and the use of computer as a tool. His job is not to apply proven principles but to prove new ones, in the view of Mr. McMullen.

WINNIPEG

P. M. Abel, JR.E.I.C., *Correspondent*

NATIONAL RESOURCES PLANNING IN MANITOBA was summarized on January 29 by S. W. Shortinghuis, assistant deputy minister, Mines and Natural Resources, Manitoba. The speaker described the aims, problems and policy in the fields of forestry, fisheries, furs, water resources, flood and erosion control, big game, provincial parks, geologic surveys and mining, and soil surveys, etc.

The speaker also commented on the Arthur D. Little report, "Economic Survey of Northern Manitoba."

This was the annual meeting of the branch, at which reports of the year's activities were given. A new slate of officers was introduced by the new chairman, W. L. Wardrop.

• OTHER SOCIETIES

Association of Consulting Engineers of Canada

At the first phase of the annual meeting of the Association, held on February 16, C. C. Parker, M.E.I.C., of Hamilton, Ont., was named president for the coming year.

J. G. Frost, M.E.I.C., of Montreal, retiring president, was heartily congratulated upon his work. Vice-president of the Association is R. R. Duquette, M.E.I.C., Montreal; J. H. Ross, M.E.I.C., Toronto, is honorary secretary-treasurer. The Board of Directors is now composed of: C. C. Carruthers, M.E.I.C., Toronto; J. E. Dion, M.E.I.C., R. R. Duquette, M.E.I.C., J. A. Kearns, M.E.I.C., Montreal; N. H. Lawrence, M.E.I.C., Edmonton; A. D. Margison, M.E.I.C., J. H. Ross, M.E.I.C., Toronto; C. C. Parker, M.E.I.C., Hamilton. Ex-officio members of the Board are three immediate past presidents: J. G. Chenevert, M.E.I.C., Montreal; J. F. MacLaren, M.E.I.C., Toronto, and J. G. Frost, M.E.I.C., Montreal.

R. G. Gould, secretary for the past eight years has resigned. He is succeeded by Col. J. M. Muir of Toronto.

The second phase of the annual meeting will convene June 9, 1959, at the Royal York Hotel, Toronto.

Fifth Nuclear Congress
Cleveland, Ohio, April 5-10, 1959.

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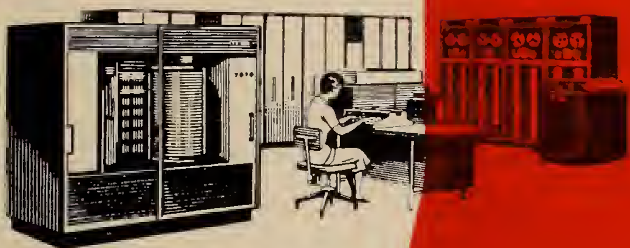

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BOOK NOTES

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.

*MODERN SAFETY PRACTICES

Stresses the need for designing safety programs to conform to modern management practices and newly developed and tested concepts of safety organization and administration. The safety program is presented in four phases: the development of safe working conditions; job hazard analysis and personalized safety training; promotion of employee safety participation; enforcement of safety rules. Among other features, the book outlines consultative methods for safety engineers. (R. DeReamer. New York, Wiley, 1958. 357p., $7.00.)

*INTRODUCTION TO THE DESIGN OF SERVO-MECHANISMS

Gives a basic explanation of stability and feedback design, both single and multiple loop. The author attempts to provide a systematic approach to design problems and the principal performance requirements entailed such as harmonic response, time response, error coefficients, and noise response. Attention is also given to the common aspects of non-linear operation, and an appendix is included which covers servo-mechanism components. (J. L. Bower and P. M. Schultheiss. New York, Wiley, 1958. 510p., $13.00.)

EMPIRE AND COMMONWEALTH YEAR BOOK, 1958-9

The seventh edition of this useful reference work contains for the first time a cost of living index for Commonwealth countries, and a list of principal banks in all countries. The book is divided into three sections, the first of which contains miscellaneous information on Commonwealth organizations, trade, conferences, etc. The second section gives for each of the 80 countries and territories information on geography, climate, history, constitution, government, communications, area, population, education, trade, etc. The final section gives statistics on the production of raw materials and commodities in the Commonwealth. (Ed. by R. S. Russell. London, Newman Neame, 1958. 569p., 50/-.)

*ECONOMIC OPERATION OF POWER SYSTEMS

A presentation of new analytical and computing techniques that have resulted in significant savings for electric utilities. The author shows how matrix methods are employed to derive transmission-loss formulas, which form the basis for computational procedures utilized in digital computers. The application of analogue and digital computers to the problems of calculating transmission-loss formulas and generation schedules is also treated. (L. K. Kirchmayer. New York, Wiley, 1958. 260p., $12.00.)

DIE WISSENSCHAFTLICHE FACHBIBLIOTHEK

This volume is written mainly for Special Library librarians, who have no formal training. It serves as a methodical introduction to the work, and as a foundation for further development. It discusses the position and the operation of a library in an industry or a scientific institution, and gives the basic concepts and practices of daily library work. (J. Bramer and D. Vogel, Leipzig, Veb Otto Harrassowitz, 1956. 177p. DM 8,20.)

*KNOCKING CHARACTERISTICS OF PURE HYDROCARBONS

A study of a wide variety of pure hydrocarbons for the purpose of relating their structures and physical characteristics to their respective knock limitations in engines. Various engine types and operation procedures were utilized to take into account the effect of these variables on knock ratings. The study was developed under the American Petroleum Institute Hydrocarbon Research Project. (Philadelphia, American Society for Testing Materials, 1958. S.t.p. no. 225, 96p., $6.00.)

*THEORETICAL ELECTROMAGNETISM

Covers the following areas: electrostatics, magnetostatics, electromagnetic induction, Maxwell's equations and circuit concepts, electromagnetic waves, and a selected group of worked out problems in electrostatics. Vector methods are used throughout and the rationalized meter-kilogram-second-coulomb system of units has been adopted. (W. R. Myers. Toronto, Butterworth, 1958. 274p., $8.50.)

PROGRESS IN CARGO HANDLING, VOL. 2

The emphasis at the Third General Technical Conference of the International Cargo Handling Co-Ordination Association reported in this volume was on methods of improving the handling of merchandise on board ship. The papers and discussion in this section covered the handling of general cargo; research in cargo handling; the use of the pocket elevator; stowage; and container ship design.

The second symposium considered the marking of general cargo, and the handling of frozen meat. The third symposium discussed containers, and the fourth fruit handling. (Toronto, British Book Service, 1958. 306p., $12.75.)

*VISTAS IN ASTRONAUTICS. FIRST ANNUAL AIR FORCE, OFFICE OF SCIENTIFIC RESEARCH, ASTRONAUTICS SYMPOSIUM

The forty papers included in this symposium are presented under six major headings: re-entry problems of satellite vehicles, both dynamic and thermodynamic; tracking and communications for satellites and other space vehicles; environment and measurements, radiations in the high atmosphere; propulsion of space vehicles, including the plasma jet; orbit study and control; human factors in connection with space flight. (Ed. Morton Alperin and others. New York, Pergamon Press, 1958. 330p., $15.00.)

*THE PLASMA IN A MAGNETIC FIELD: A SYMPOSIUM ON MAGNETOHYDRODYNAMICS

Papers examining how magnetic fields influence and are influenced by plasmas. Section one deals with simplification of the orbit analysis of important configurations, while section two deals with the instability occurring at the interface between a plasma and a magnetic field. The concluding section deals with the transfer of energy between a magnetic field and a plasma. (Ed. by R. K. M. Landshoff. Stanford, Calif., Stanford University Press, 1958. 130p., $4.50.)

*AIRCRAFT AND MISSILE PROPULSION, VOL. 2

This volume, which is the second in a series of three, discusses the methods for analyzing and determining the performance characteristics of the gas-turbine power plant, the turboprop engine, the turbojet engine, the ramjet engine, and the liquid propellant and solid propellant rocket engines. Deriva-

tions of the principal equations are explained in detail, and a large number of exercise problems are included along with the answers. A considerable number of references are included at the end of each chapter. (M. J. Zucrow. New York, Wiley, 1958. 636p., $13.00.)

DESIGN OF AIR CONDITIONING SYSTEMS

Intended as a companion volume to the author's Design of Heating and Ventilating Systems, the emphasis in this book is on techniques of solving problems in air conditioning. Graphical solutions are given for many of the equations, and the use of the graphs will eliminate much calculation. The book covers psychrometrics, the cooling load, solar energy, comfort levels, air flow through ducts and fittings, the noise problem and panel cooling design. (F. W. Hutchinson. New York, Industrial Press, 1958. 336p., $7.00.)

ELECTRIC FURNACES

The industrial applications of electric furnaces are discussed in this volume which commences with a brief description of the three types: arc and induction for high temperature; induction and indirect resistance for low temperatures; and high-frequency capacitance heating and indirect-heat resistance furnaces for non-metallic materials. The industries considered include metal, glass, pottery and plastics. This is a most useful volume. (Ed. by C. A. Otto. London, Newnes, 1958. 248p., 35/-.)

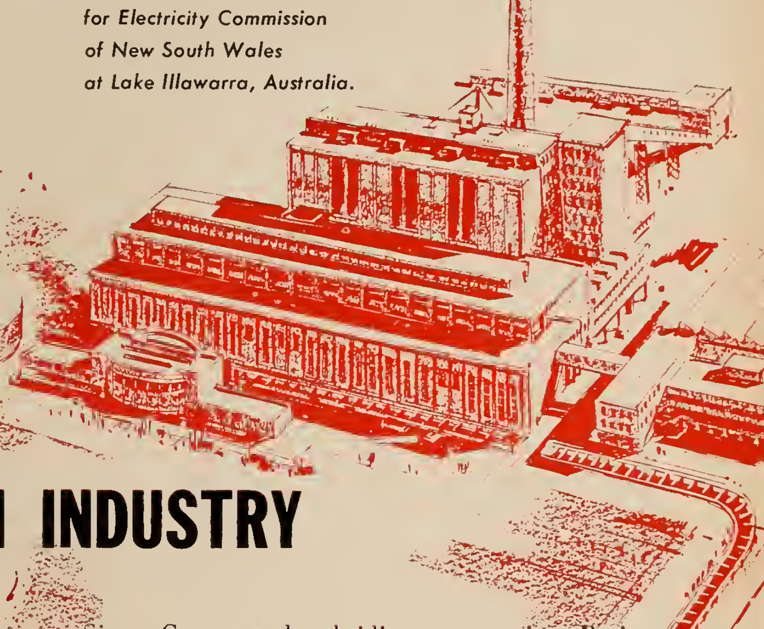
LINEAR PROGRAMMING FUNDAMENTALS AND APPLICATIONS

Intended primarily for management, this volume presents the fundamentals of linear programming and its applications in non-technical language. After a brief introductory section, the second section considers methods used, including two developed by the authors, and a time-saving refinement, MODI, of another of their methods. In the chapters on applications, examples are taken from actual case studies. There is a useful bibliography, and the appendix contains a mathematical description of the Simplex Method, and a comparison of the Simplex and Modi Methods. (R. O. Ferguson and L. F. Sargent. Toronto, McGraw-Hill, 1958. 342p., $10.00.)

°BEMESSUNGSVERFAHREN, 16TH ED.

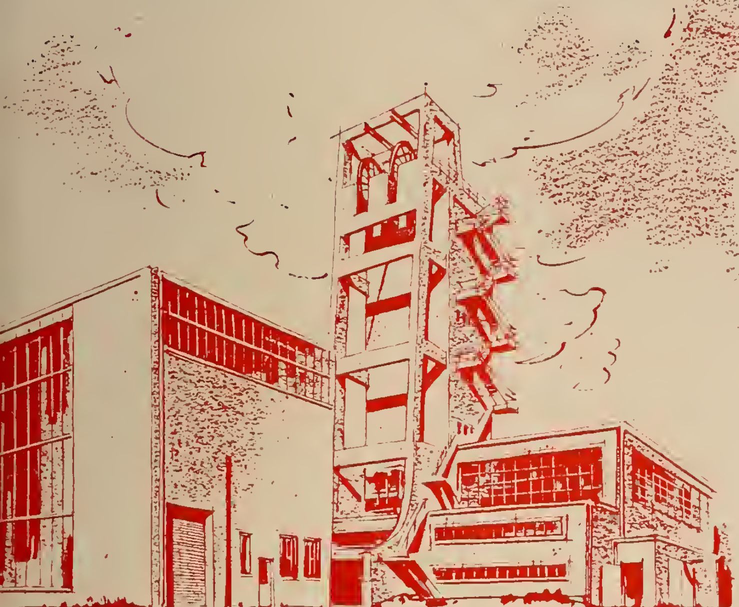
A manual of design procedures which are in accordance with the specifications and codes of the German Committee on Reinforced Concrete. It covers exterior forces on structures, bending, torsion, shear stresses, bond stresses, materials, flat slabs, special reinforcements, and various special cases such as roof slabs with glass inserts. The text is preceded by a list of the pertinent German (DIN) standards. (Benno Loser, rev. by Helmut Loser. Berlin, Wilhelm Ernst and Sohn. 1958. 351p., 26 DM.)

Sulphuric Acid Plant
for Sulphuric Acid Ltd.
at Adelaide in Australia.



Tallawarra Power Station
for Electricity Commission
of New South Wales
at Lake Illawarra, Australia.

To Serve CANADIAN INDUSTRY



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and winding water house
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• LIBRARY NOTES

MINING EXPLOSIVES

Intended both for students and those engaged in mining and quarrying, this volume commences with a brief review of the history of explosives. The next six chapters describe the characteristics, composition and construction of blasting explosives and accessories. The next four chapters covers blasting in collieries, metalliferous mines, quarries and opencast workings. The final chapters deal with the storage and transport of explosives, and accident prevention. The text is illustrated with line drawings. The authors have had considerable experience in the field. (R. McAdam and R. Westwater. London, Oliver and Boyd, Toronto, Clarke, Irwin, 1958. 187p., $4.75.)

ELEMENTARY REINFORCED CONCRETE DESIGN, 2ND ED.

This new edition includes a comprehensive treatment of the load factor method of design permitted in the 1957 British Standard Code of Practice on the structural use of reinforced concrete in buildings. The Load Factor and Elastic Theory methods of design are compared, and chapters have been added dealing with retaining walls, prestressed concrete and beams of non-rectangular cross section.

The text is intended primarily for students. The topics covered include general structural mechanics, slabs and beams, columns and their footings, staircases and hollow tile floors. (W. Morgan. Toronto, Macmillan, 1958. 408p., $4.75.)

*PROGRESS IN SEMICONDUCTORS: VOL. 3

A selective review of current developments in the field of semiconductors that discusses the following topics: the magnetoresistivity of germanium and silicon; electronic conductivity of silver halide crystals; silicon junction diodes; lifetime of excess carriers in semiconductors; chemical purification of germanium and silicon; scattering and drift mobility of carriers in germanium; electronic processes in cadmium sulphide. (Edited by A. F. Gibson and others. New York, Wiley, 1958. 210p., $8.50.)

*REFERENCES ON FATIGUE

A list of references to articles published in 1957 dealing with fatigue of structures and materials. References are so arranged that sheets can be cut apart for filing according to any desired plan. Brief abstracts are included when readily available. (Philadelphia, American Society for Testing Materials, 1958. 64p. (s.t.p. no. 9-1) $3.00.)

*REPORT ON ELEVATED-TEMPERATURE PROPERTIES OF CHROMIUM STEELS

A graphic summary of the elevated temperature strength properties for chromium steels (12-27 per cent). It includes data on tensile strength, yield strength, elongation, rupture, and creep properties. Twenty-three alloys are covered ranging from 12 to 27 per cent chromium. (Philadelphia, American Society for

• LIBRARY NOTES

Testing Materials, 1958. 113p. (s.t.p. no. 228) $4.25.)

°COASTAL ENGINEERING, PROCEEDINGS OF THE SIXTH CONFERENCE, 1957

Papers dealing with wind, waves, and wind tides, with considerable emphasis on the hurricane; coastal sediment problems; coastal engineering problems; coastal structures and related problems; including breakwaters, wave absorbers, and sea walls. The theoretical aspects of the subject are covered as are specific problems in various localities. (Richmond, Council on Wave Research, Engineering Foundation, University of California, 1958, 896p.)

ON THE OLD LINES; LOCOMOTIVES ROUND THE WORLD, 2ND ED.

The author's personal record of the trains he has seen in thirty-seven countries. His photographs are nearly all of steam trains — he has little use for the diesel —and include coal burning, wood burning, narrow-gauge, wide-gauge, mountain railroads. Mr. Allen is fascinated by his subject, and so will his reader be. This second edition includes more photographs from Africa and Mexico. (Peter Allen. London, Cleaver-Hume, 1958. 190p., 25/-.)

STUDY OF SEVERAL AEROTHERMOELASTIC PROBLEMS OF AIRCRAFT STRUCTURES IN HIGH-SPEED FLIGHT

The emphasis in these reports is on dynamic aeroelastic effects. The first section deals with temperature within the structure, and stress and stiffness analysis of structures with temperature gradients. The second section considers aeroelastic phenomena, and discusses the determination of frequency response surface influences, flutter analysis, and panel flutter. This is a thesis written for the Eidgenossische Technische Hochschule in Zurich. (J. C. Houbolt. Zurich, Leemann, 1958. 108p., 12 Sw. Fr.)

°THERMODYNAMIC PROPERTIES OF WATER AND STEAM, 6TH ED.

Following preliminary material on the association theory of real gases, superheated steam, and the thermodynamic relations for dry saturated steam and boiling water, tables are given for the thermodynamic properties of water and steam up to pressure of 800-1000 a t a and temperatures of 1000°C. In setting up the tables for the high temperatures, the authors have extrapolated certain values from the experimental data available. The book is in four languages, English, French, Russian and German, printed in adjoining columns. (M. P. Vukalovitch. Berlin, VEB Verlag Technik, 1958. 245p., 20 DM.)

°CREATIVE THINKING

The major portion of the book is concerned with operational techniques of creative thinking, including group discussion methods and analytical or mechanical techniques that groups have found useful in stimulating new ideas.

Among those methods presented are the Gordon technique and brainstorming. The book concludes with descriptions of programs used by various corporations. (C. S. Whiting. New York, Reinhold, 1958. 168p., $3.95.)

GAS TUBES

Another in the basic electronics series issued by this publisher, this volume covers ionization in gases, gaseous rectifiers, gas tube voltage regulators, thyratrons and other types of gas tubes. The book is intended to explain the fundamentals of gas-tubes and their applications in electronics. (Ed. by A. Schure. New York. Rider, 1958. 72p., $1.50.)

LIGHT

Commencing with an explanation of the four concepts of the nature of light, corpuscular, wave, electro-magnetic and quantum, the book also covers in more detail reflection, refraction, the wave nature of light, the spectrum, both visible and invisible, optical instruments and illumination. (A. Efron. New York, Rider, 1958. 127p., $2.25.)

FUNDAMENTALS OF TRANSISTORS, 2ND ED.

This revised edition includes material on the theory, construction and operation of semiconductor devices such as surface barrier, intrinsic, drift, avalanche and spacistor types. The topics covered include semiconductor physics, the grounded base transistor, the grounded emitter and grounded collector transistors, transistor amplifiers and oscillators, and transistors at high frequencies. References are included. (L. M. Krugman. New York, Rider, 1958. 168p., $3.50.)

BASIC PULSES

A very basic "picture book" introduction to pulses, requiring some knowledge of electronics. It explains the composition, shaping techniques, measurement, generation and application of pulses, and is suitable for students, technicians and others wishing to study the subject at home or in class. (Irving Gottlieb. New York, Rider, 1958. 175p., $3.50.)

°PROCESS DYNAMICS

An examination of the characteristics of processes under unsteady-state conditions or in response to periodic disturbances. Those aspects treated include kinematics of materials handling; fluids in motion; forming, propulsion, and guidance; thermal process dynamics; mass transfer dynamics; chemical process dynamics. A special feature is the coverage given to methods for controlling process operations involving moving filaments, sheets and webs. (D. P. Campbell. New York, Wiley, 1958. 316p., $10.50.)

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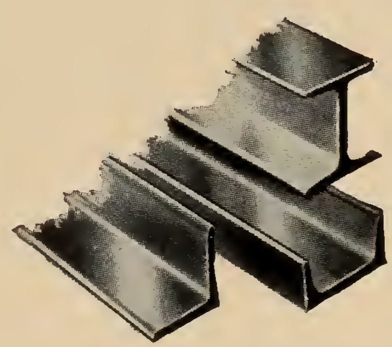

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are Roy A. Nicholson Limited, Burlington, Ont. and Lord and Burnham Company Limited, St. Catharines, Ont. It is estimated that the film will last three winters and two summers on roof surfaces and five years on vertical exposures. It has been designed to withstand temperatures ranging from -60 degrees to 200 degrees Fahrenheit.

Hexagon Bolts. — The Steel Company of Canada, Ltd., Hamilton, Ont. has announced an important fastener industry simplification. The standard square head machine bolt and cap screws are being replaced in sizes ¼" through 1" diameter and 6" and shorter with a hexagon head and hexagon nut to be known as "Hexagon Bolts".

It is claimed that the advantages are improved quality, better appearance, lighter weight, easier and faster work on the assembly line. These new products will also simplify specifications and number of parts required for stock. For further details write to the company.

DuPont Sales — DuPont Company of Canada Limited has announced its sales in 1958 amounted to $81,680,000, an increase of 12 per cent over the previous year.

Railway Wage Agreement — Wage increases totalling nearly 10 per cent are included in the terms of a three-year agreement reached between the Canadian National Railways and 21,000 of its employes represented by the Brotherhood of Railway Trainmen. The agreement calls for wage increases in four stages and a number of rule changes. The employes affected are trainmen, conductors, baggagemen, brakemen, yardmasters, yardhelpers, switch tenders and yard-foremen.

Pirelli Expansion — Pirelli Cables, Conduits Limited has opened a new warehouse in Montreal, which has doubled the usable floor area to over 17,000 sq. ft. This new warehouse is one of a chain extending from St. John's, Newfoundland to Vancouver. In all branches heavy wire and cable stocks are kept on hand.

Dominion Bridge Change — Dominion Bridge Company, Limited recently announced that owing to the widening activities of its wholly-owned subsidiary, Standard Iron & Engineering Works Ltd., that organization will now be known as the "Edmonton Branch" of the parent company.

Esab Opens Canadian Office — Esab, a Swedish company, the founder of which, Oscar Kjellberg, originated the electrode and pioneered the craft of welding, has opened a Canadian office at 1215 Greene Avenue, Westmount, Montreal. There is also a warehouse branch at 222 Front Street East, Toronto. The name of the Canadian company is Esab Arc Rods Limited and it will be under the direction of Gustav Smith.

Water Resources. — The Ontario Water Resources Commission has announced the signing of preliminary agreement with three Ontario municipalities in regard to water and sewage projects.

Two agreements were signed with Mitchell whereby the Commission agrees to undertake the construction of sanitary sewage works as well as storm sewage works. The sanitary sewage system will involve the downtown residential and commercial area and the first stage of a sewage treatment plant.

An agreement with Leamington calls for construction of a storm trunk sewer system. In the township of Ancaster in the County of Wentworth, the OWRC will build water works for that township, including an elevated tank with a capacity of 750,000 gallons.

Underwriters' List — Underwriters' Laboratories of Canada, 7 Crouse Road, Scarborough, Ont. has commenced distribution of its September 1958 list of Inspected Appliances, Equipment and Materials. This supersedes the September 1956 edition and all supplements thereto. The new list consists of 230 pages and is 20% larger than the previous addition. For further information communicate with the Laboratories.

Construction Chemicals — A newly formed company, Construction Chemicals Limited, has been appointed Ontario distributor for the Dewey and Almy Chemical Division of W. R. Grace & Co. of Canada Ltd. President of the new concern will be Harold C. Pearson of Toronto, formerly of Westmount, Que. Mr. Pearson is retiring as vice-president of the Canadian Dewey and Almy division to form the new distributorship. He has had 45 years experience with Dewey and Almy.

Boiler Cleaner — Dow Chemical Company of Canada Limited has announced the development of a new technique for hydroxy apatite boiler scale removal. It is claimed that the process developed reduces downtime as much as 30 hours for high make-up industrial boiler cleanings.

The new technique makes use of chelating agents which are introduced into the boiler solution as a water solution and circulated at low pressures until the reaction is complete. For further details write to the company.

House Moving Equipment — Brantford Coach and Body Limited, Brantford, Ont. will be pleased to give further details of their equipment and method of moving buildings.

Recently they moved a two-storey triplex a distance of four city blocks in a very short time without a hitch. The house, measuring 50 ft. x 20 ft. x 26 ft. high and weighing 140 tons is, it is believed, the first occasion on which a Brantford Coach & Body designed and built Walking Beam Trunion did the job.

Write to the company for further details.

Paper Company Changes Name — The name of Mersey Paper Company Limited, Liverpool, Nova Scotia, has been changed to Bowater's Mersey Paper Company Limited.

Bowater's Mersey, Nova Scotia's second largest industry became a member of the Bowater organization in 1956. Current output is nearly 500 tons of newsprint a day from two machines.

INSTRUMENTATION, FOOD INDUSTRY

(Continued from page 86)

thought it took at least nine years or more to write-off his investment in instruments.

General Comments

"Where processes are varied and generally of an intermittent nature, operations do not lend themselves to complete automatic control", states the manager of a large canning industry. "In many cases processes are arranged for reversion to manual control where necessary, because of instrument failure, etc. With the coming automation in packaging, more accurate automatic temperature and quality control will be required."

"During past years many processes have been changed from batch type to continuous type of operation. The advantages are obvious and not achievable without many automatic control instruments. Simple and reliable flow measuring instruments for non-neutonian fluids are required. The existing type is still too inaccurate, too complicated and too expensive."

"In summary, the future of 'automation' in the food industry depends largely on further development of proportioning controls, applied to a wide variety and condition of food ingredients. It depends on parallel further development of automatic built-in quality control checks and corrective apparatus, and further improvement in sturdiness and reliability of instruments to avoid costly shut-downs of long continuous lines."

"Future trends are to a degree with us now", is the opinion expressed by a flour and cereal producer. "A punched card can start a process, operate it and shut it off when complete; in other words, push-button operation is today a reality. Without instrumentation and automatic process control of the food industry could not remain alive in today's competitive market. Greatly increased use of instrumentation is predicted as the food industry progresses toward more automation."

THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: K. F. Tupper, M.E.I.C. — Treasurer: T. W. Eadie, M.E.I.C. — General Secretary: Garnet T. Page, M.E.I.C

Editor: Garnet T. Page, M.E.I.C.

Assistant Editor: Margaret Griffin — Associate Editor: J. Hance Legere, M.E.I.C. — Assistant Editor (Production): John Cherer

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APRIL 1959

vol. 42 no. 4

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

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MEET THE AUTHORS

C. E. Frost, M.E.I.C., regional buildings engineer, eastern region, Bell Telephone Company, *(Quebec Labrador Tropospheric Scatter Radio System.)*

Mr. Frost graduated from McGill University in 1931 with a degree in civil engineering. He began to work for the Bell Telephone Company in 1937 until he joined the RCAF as a construction engineering officer in 1942.

In 1945 he returned to the Bell Telephone Company, and served as a member of the chief engineer's staff, and two years later was appointed special studies engineer. In 1951 Mr. Frost was appointed to the Regional Buildings Engineer's staff as construction contract engineer and was responsible for design and construction of structures to operate the first tropospheric scatter system installed anywhere in the world.

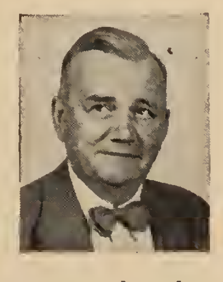
C. L. Emery, M.E.I.C., lecturer Queen's University. *(Design of a Functional Structure in or on Rock.)*

A graduate from Queen's University in 1936 (B.Sc. (honours), mining engineering) he received his M.Sc. there in 1958.

Mr. Emery has done mining, milling and field work in Ontario, British Columbia and Western United States. He has had experience in consulting, teaching and administration in high schools, technical institute and university.

At present he is doing consulting work in mining and structural design in Ontario.

Mr. Emery is a member of the Association of Professional Engineers of Ontario, of the A.S.E.E. and of the Canadian Institute of Mining and Metallurgy.



A. V. Corlett, M.E.I.C., Algoma Ore Properties Professor in Mining Engineering, Queen's University; and Head of the Department of Mining Engineering. *(Design of a Functioning Structure in or on Rock.)*

Professor Corlett received his B.Sc. degree in mining and metallurgy from Queen's University in 1922.

He has worked on oil well drilling in S.W. Ontario and Portuguese West Africa, on mining in Porcupine, on prospecting and exploration in Ontario, Quebec and Newfoundland. In 1936 he was mine manager in Western Quebec, and the Eastern Townships of Quebec for Aldermac Copper Corporation, later manager of the Normetal Mining Corporation. In 1958 he joined Queen's University staff and supplements his work by limited engineering consulting.

He is a member of the Professional Engineers of Quebec and Ontario and of the C.I.M., A.I.M.E. and A.S.E.E.

D. J. McDonald, M.E.I.C., area radio engineer, Toll Area, Bell Telephone Company, *(Quebec Labrador Tropospheric Scatter Radio System).*

Graduating from Queen's University in 1926 with a B.Sc. Mr. McDonald worked in various phases of transmission and radio engineering for the Bell Telephone Company of Canada.

His was the responsibility for direction of radio systems in the engineering of the "Pole Vault" system in Newfoundland and Labrador.

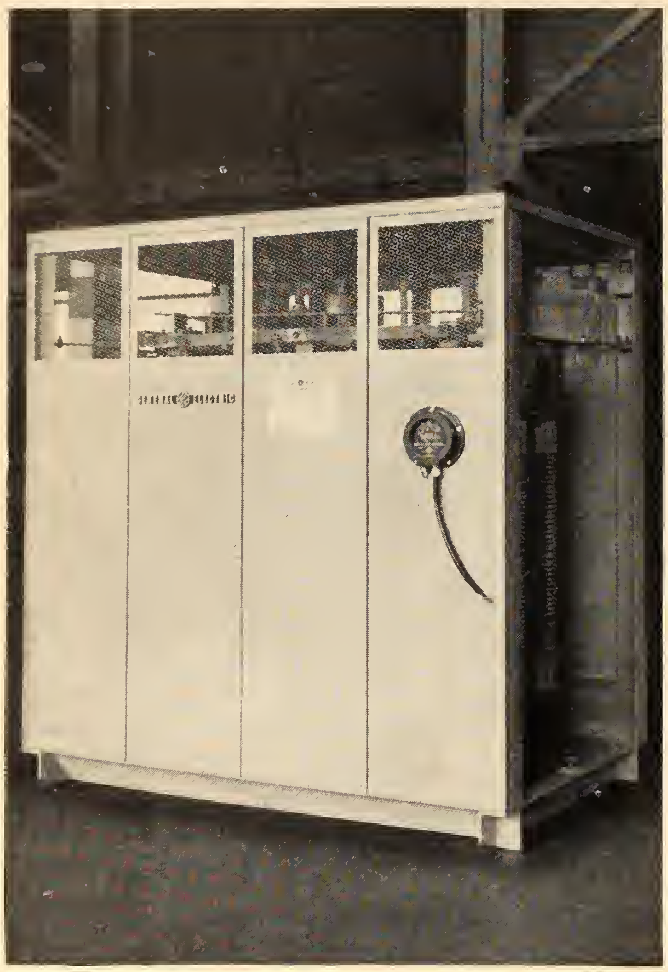
Mr. McDonald is a member of the Corporation of Professional Engineers of Quebec and the Institute of Radio Engineers.

R. G. Fuller, M.E.I.C., engineering and management consultant, Peacock Brothers Limited, Ville LaSalle, Que. *(The Free Piston Engine.)*

Mr. Fuller was educated in England where he was concerned with Power Generation and Utilization. In 1937 he went to the Far East for the British American Tobacco Company and was responsible for modernizing their extensive plants. In 1941 he was responsible for manufacture of naval equipment in Hongkong as director of Marconi's Wireless Telegraph Company (China) Limited. He joined the Brush Group in 1949 and after completing a world tour was appointed director of their engine export companies. Subsequently Mr. Fuller pioneered the Free Piston Engine for Associated British Engineering as director of their Canadian affiliate, and is now engaged in organizing a Free Piston Engine and Gas Turbine division for Peacock Brothers Limited.

Mr. Fuller is a member of many societies and corporations among which are: The Corporation of Professional Engineers of Quebec; Institute of Electrical Engineers (England), The American Institute of Electrical Engineers and the Canadian Chamber of Commerce.

The Engineering Institute wishes to extend its thanks to the following for their contribution to the paper appearing in this month's issue, *Deas Island Tunnel.* D. A. Young, M.E.I.C., assistant to vice-president, Foundation of Canada Engineering Corporation Ltd.; Per Hall, M.E.I.C., president "Fenco", Ltd.; T. Brøndum-Nielsen, Copenhagen; H. R. Kivisild, M.E.I.C., district engineer, "Fenco", Ltd.; A. T. Jeffrey, supervising electrical engineer, "Fenco", Ltd.; and O. H. Bentzen, project manager, "Fenco", Ltd.



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Apparatus Department

CANADIAN GENERAL ELECTRIC

QUEBEC-LABRADOR TROPOSPHERIC SCATTER RADIO SYSTEM

D. J. McDonald, M.E.I.C., *Area Radio Engineer*
C. E. Frost, M.E.I.C., *Buildings and Structures Engineer*
Bell Telephone Company of Canada

The installation of a tropospheric scatter radio system to provide telephone and miscellaneous communication services to Schefferville and Goose Bay and to other locations in Northern Quebec and Labrador was undertaken by the Bell Telephone Company of Canada in association with Quebec Telephone. This paper is a report of the engineering and construction of the project with particular emphasis on the broad planning of the system and on the construction aspects. Part I deals with the communication systems engineering aspects; Part II deals with the design and construction of buildings, towers, roads, etc.

Part 1. Communication Systems Engineering

Goose Bay is a large military and civilian airport. It was served by a network of government-owned communication circuits for defence purposes but commercial communication service available to the public was limited to a single telegraph channel. The Canadian and United States Armed Services owned and operated local telephone systems for their own use, but service to the public was limited to lines important to the military establishments. There was urgent need for commercial telephone service in Goose Bay, for long-distance circuits, and for additional defence circuits; it was important that they be provided over routes widely separated from the existing government-owned systems.

Figure 1 is a map of the area showing main centres requiring communication facilities.

Schefferville, the northern terminus of the Quebec North Shore and Labrador Railway and the centre of the Iron Ore Company of Canada's mining operations, was given telephone service by the Ungava Telephone Company, an Iron Ore Company subsidiary. Long-distance circuits from Seven Islands were provided by a carrier system operating on open wire on the joint power and communication pole line built along the Quebec North Shore and Labrador Railway. The new requirement was for communication circuits for the Mid-Canada Line and other defence operations.

In addition to these established communities, there is activity at many other developing locations, such as the power development at Grand Falls on the Hamilton River, and the mining operations near Wabush Lake and Mount Reed. There is also need for communication north from Schefferville towards the Ungava Bay mining operations.

Planning Studies

The tropospheric scatter type of radio system, with its ability to span long distances between stations, is ideally suited for use to places like Goose Bay and Schefferville. Study indicated that the logical route for the facilities southward should be through Seven Islands, then served by Quebec Telephone. Negotiations were opened with the Royal Canadian Air Force concerning telephone service in Goose Bay, and with Quebec Telephone regarding the broad planning of the system.

The conclusions were that a central office and telephone plant would be installed in Goose Bay by the Bell Telephone Company of Canada to provide local service, and that long-distance circuits to Rimouski and Quebec would be provided by Bell Telephone and Quebec Telephone, each in its own territory. The conventional line-of-sight microwave type of system would be used for the long distance circuits from Quebec to Seven Islands, and the tropospheric scatter type of radio system from the vicinity of Seven Islands to Goose Bay and Schefferville.

This paper is concerned with the tropospheric scatter part of the overall project. For the rest, briefly, Lenkurt 74A microwave equipment operating in the 6000 Mc/s. band was selected for a 16-mile hop from the scatter station at Trouble Mountain to Seven Islands, and TD-2 microwave equipment (4000 Mc/s. band) for the part from Seven Islands back to Rimouski and Quebec.

There are six radio stations in the tropospheric scatter system. The station at the Seven Islands end of the system (Trouble Mountain) was in Quebec Telephone territory and was built and owned by them. The overall system was designed by the Bell Telephone Company of Canada, who acted as consultants to Quebec Telephone for the Trouble Mountain station.

Tropospheric Scatter Radio Propagation

The tropospheric scatter mode of radio propagation has been treated extensively in the technical journals. The most comprehensive single source of information is Proc. Institute of Radio Engineers, October 1955.

Radio signals in the upper VHF and higher frequency bands can be received at distances well beyond the visible horizon with sufficient power to provide reliable communication. The received signal varies extensively, the fading being of two principal types, fast and slow. The fast fading is caused by multipath transmission, and the rate of fading increases as frequency or distance is increased. Over short intervals of time the instantaneous signal has approximately a Rayleigh distribution. For example, a 20 db fade is expected about one per cent of the time and a 30 db fade for only 0.1 per cent of the time. The slow fading, for which a single cycle of variation may extend over a period of several hours, is generally independent of frequency and appears to be the result of changes in the average refraction in the atmosphere. The variation in hourly median values follows a normal probability law in decibels with a standard deviation of about 8 db[1].

In temperate latitudes the monthly mean signal is substantially higher in summer than in winter. In the 750 to 1000 Mc/s. frequency band the monthly mean signals for summer and winter may be 10 db higher and lower respectively than the yearly mean signal.

The radio transmission loss on long paths is higher than the line-of-sight path loss for the same distance. This, together with the wide fading range, makes it necessary to use high power transmitters, high gain antennas, and sensitive receivers to obtain reliable communication.

The generally accepted theory of tropospheric scatter propagation is that radio energy from a transmitting antenna is partly scattered by inhomogeneities in the lower atmosphere or troposphere. Some of it is re-radiated in all directions, a small part being back to the earth and in the same direction as the original beam from the transmitter. For a given antenna system and radiated power, the mean received power is dependent on:

(1) The distance between the transmitting and receiving stations.

(2) The angle to the horizon as seen from each station, looking in the direction of the path.

(3) The foreground clearance in the immediate vicinity of the antenna; that is, within the first few miles.

Referring to Fig. 2, A and B are the two stations and the antenna directional beam patterns are along the lines AC and BC.

The propagation loss or radio transmission loss increases with increasing distance between points A and B; this corresponds to increase in the angle θ. Further analysis shows that a positive horizon angle at either or both stations is equivalent to further increasing the value of θ and indicates why a positive horizon angle increases the transmission loss whereas a negative horizon angle reduces it.

Adequate ground clearance is required in the immediate foreground of the antenna for it to establish its full directional beam pattern.

It was planned to use tropospheric scatter radio equipment of the general type already used on defence projects in Northern Canada. Important characteristics are: (1) Operation in the 750 to 980 Mc/s frequency band. (2) Transmitters available with 2 kw. or 10 kw. output. (3) Frequency diversity receivers of the combiner type. (4) Parabolic antennas of up to 60 ft. reflector diameter. (5) Assurance of handling up to 130 voice channels with the promise of more.

System Planning Criteria

The planning of a communication system such as this requires compliance with certain criteria.

(1) Communication channels to service points in the territory must be by terminal or repeater stations at those points or, if located elsewhere, by branch systems extended to the service points.

(2) The system must provide the number of channels required now and must be capable of future expansion, preferably so that it can be integrated with a larger-capacity system if needed.

(3) The performance of the system should be adequate for the service to be handled. In this case the requirements were to be the same as for the continental long-distance circuits.

(4) Construction and operation costs must be reasonable.

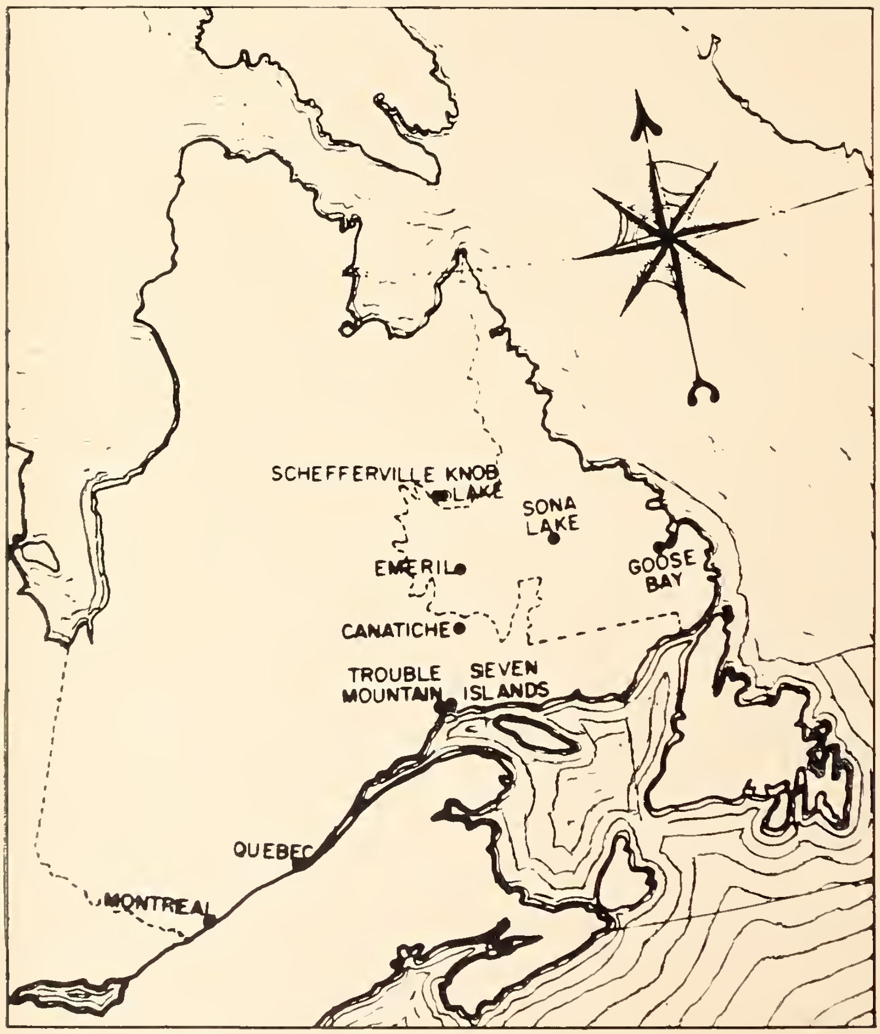
(5) Design and operation of the system must comply with regulations of the Department of Transport, which regulates radio stations in Canada.

(6) Where defence circuits traverse isolated regions, protection against sabotage and enemy action must be considered. The small number of stations in a tropospheric scatter radio system is an advantage.

Broad cost studies of tropospheric scatter radio systems and comparable line-of-sight microwave systems showed that the controlling factor is usually the nature of the access to the radio stations both for construction and for maintenance. If the sites for a line-of-sight system are accessible at reasonable cost from an established highway, then, in general, such a system can be built and maintained at lower cost than a corresponding tropo-scatter system. If access is by railway, the answer is not so clear because maintenance operations will depend greatly on the location and mode of operation of the railway.

Where access to the intermediate stations of a line-of-sight system is difficult and costly, the scatter system is usually cheaper to build and operate.

Fig. 1 Map of the area showing main centres requiring communication facilities.



Radio Frequency Allocations

The radio equipment for this project is designed to operate in the frequency band from 755 Mc/s. to 980 Mc/s. This overlaps the upper part of the UHF-TV broadcast band, which extends from 470 Mc/s. to 890 Mc/s., and the industrial, scientific and medical band from 890 Mc/s. to 940 Mc/s. Radio communication services in the latter band are not protected against interference from industrial, scientific and medical equipment. Control of interference to TV reception is a vital factor. International regulations require that the stations do not interfere with reception in other countries, and in this case the United States is of prime concern. In Canada, the stations are under the jurisdiction of the Department of Transport and control is exercised by issuing temporary radio station licenses subject to non-interference.

It is essential to separate the frequency assignments of the transmitters and receivers, operating at a particular station, by a substantial amount. Typical values for the equipment used in this project are 96 Mc/s. between the transmitter and receiver at one end of a relay section and 60 Mc/s. between the transmitter in one direction at a relay station and a receiver in the opposite direction at the same station. Because of the long-range propagation characteristics of the scatter mode, there are restrictions on how many transmitters in a multi-hop system may use the same frequency. These factors limit the number of separate systems which may terminate at a particular location or operate in a given territory.

Final System Plan

In Canada, tropospheric scatter systems in the 755 to 980 Mc/s. band are attractive only in regions of sparse population, remote from the United States boundary and where access to intermediate points is difficult and costly.

The preliminary planning established that the facilities should be tropospheric scatter from the vicinity of Seven Islands to Schefferville and Goose Bay and that the intermediate stations between Seven Islands and Schefferville should be close to the Quebec, North Shore and Labrador Railway. Still to be resolved were the number and location of these intermediate stations and the site of the station between the railway and Goose Bay; for the latter, Grand Falls on the Hamilton River was indicated as suitable. British Newfoundland Corporation Limited has done extensive preparatory work on the development of power at Grand Falls, where there will eventually be a substantial need for telephone service. For the stations between Seven Islands and Knob Lake, two basic plans were: one intermediate station with 10 kw. transmitters; and two intermediate stations requiring only 2 kw. transmitters. The latter plan was adopted, though overall costs for each plan were of the same order, mainly because:

(1) It is possible that the lower power transmitter need only be partially attended, and later unattended for at least part of the year.

(2) Two intermediate stations permit greater flexibility in establishing branches to other service locations.

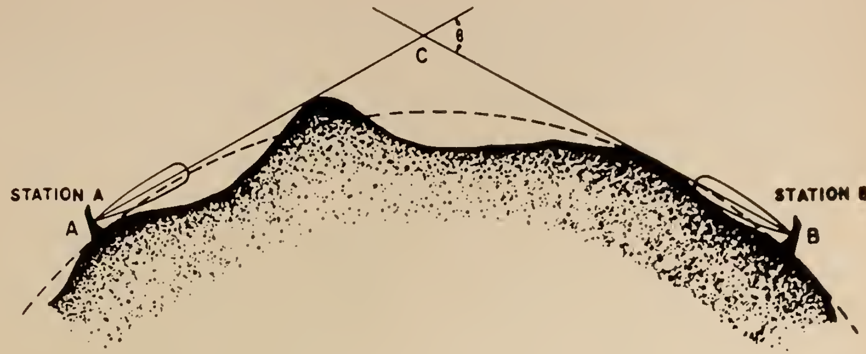


Fig. 2 Typical path profile: Tropospheric Scatter Radio System.

Site Selection

Site selection for a tropospheric scatter radio system is complex, comprising office study of maps and aerial photographs, field surveys, and further office studies. Many combinations were studied before reaching a final selection from the possible sites.

The prime criteria for the selection of sites are:

(1) Suitability for radio transmission.

(2) Feasibility of extending communication from terminals or other service points.

(3) Suitability for construction and maintenance of the radio station and associated facilities.

(4) Year-round access to the site.

Trouble Mountain

This is the southern terminus of the scatter system. The preferred location would be close to Seven Islands but the excessive positive horizon angle over the hills to the north made a site there impracticable. Trouble Mountain is 16 miles west of Seven Islands and closer to Clarke City. It is also a relay station on the TD-2 microwave system from Rimouski to Seven Islands, and a terminal station of the Lenkurt 74A microwave system between that point and Seven Islands.

The elevation of Trouble Mountain is 940 feet and the horizon angle towards the Canatiche station to the north is +18 minutes.

Canatiche

This site (elev. 2940 ft.) is 90.5 miles north of Trouble Mountain, 4 air-miles east of the Q, N.S. and L. railway. The railway here is in the Wacouna River valley and a suitable site must be at least 1000 ft. higher. The site chosen, from several, had the best radio performance commensurate with access and construction costs.

The horizon angles are -19 minutes south and -22 minutes north. An unobstructed view in all directions provides excellent potential for branch radio systems to serve neighbouring points.

Emeril

This site (elev. 2450 ft.) is 131.1 miles north of Canatiche, 5 air-miles east of the Q, N.S. and L. railway. It is the junction point for branches towards Schefferville and Goose Bay. The site had to be on a range of hills east of the railway to obtain satisfactory performance towards Goose Bay, and was selected, from three possibilities, on the basis of both radio performance and cost.

The horizon angles are: -13 min. towards Canatiche; -21 min. towards Knob Lake; -13 min. towards Sona Lake.

The horizon angle is favourable in all directions so this site lends itself to branches to other points.

Knob Lake

The site (elev. 1900 ft.) is 3 miles east of Schefferville and 118.4 miles north of Emeril, in a commanding position over the relatively flat country to the south. A road to within a few hundred feet of the site, together with favourable radio performance, made it an obvious choice. Horizon angle towards Emeril is -12 min.

Sona Lake

The site (elev. 1900 ft.) is 16 miles east of Grand Falls and about 3 miles east of the townsite which the British Newfoundland Development Corporation proposes to build for the power development. It is on the highest nearby hill, and is so much better in radio performance than any other readily-accessible point that it was an obvious choice.

Horizon angles are -12 minutes to the west and -10 minutes east. The distance from Emeril is 97.0 miles.

Goose Bay

The site (elev. 825 ft.) is on a hill 6 air-miles west of Goose Bay airport, and about 700 feet higher than the flat land on which the airport and town are built. A road to within ¾-mile of the site and the fact that there was no other suitable site nearby made the choice easy.

The horizon angle towards Sona Lake (137.4 miles) is +23 min.

TROPOSPHERIC SCATTER RADIO SYSTEM

The radio equipment operates in the frequency range 755 to 980 Mc/s. It is a broad band FM system with pre-emphasis and de-emphasis partly to equalize noise performance across the base band.

The receivers are designed for combiner-type diversity operation arranged for dual or quadruple diversity; the latter is used in this project (Fig. 3). Two antennas installed at a terminal are spaced 200 ft. apart to provide effective space diversity. In the transmitting direction, each antenna is fed from a separate power amplifier. One antenna is vertically polarized; the other horizontally. In the receiving direction, each antenna picks up both horizontally and vertically polarized signals and transmits them to four separate receivers. The outputs of the four receivers are combined, the baseband contribution of each receiver being proportional to the signal-to-noise ratio of the incoming signal.

The terminal station has two transmitters and four receivers in continuous operation, arranged to provide diversity and standby protection. If one transmitter fails, diversity is reduced from quadruple to the dual type but the system is still in service. If one receiver fails, diversity is again reduced but service is not interrupted. At a repeater station, the arrangement is two terminals back to back.

The broad baseband extends from 12 kc/s. to 800 kc/s. and is flat within ± 1.5 db. An order wire base band is available from 0.5 kc/s. to 12 kc/s.

The R. F. bandwidth of the receiver and of the exciter stage of the transmitter is 8 Mc/s. to the 3 db down points and the corresponding bandwidth for the power amplifiers is 6.0 Mc/s.

Intermodulation of a transmitter and receiver together is such that, when the system is loaded with uniform noise and fully deviated by noise peaks, the ratio of the noise per unit bandwidth being transmitted to that created by intermodulation in a blank space at any part of the baseband is greater than 42 db.

All units are designed to operate from either 120 volts single-phase or 208 volts 3-phase, four-wire, 60 cps. supply.

Transmitter

The transmitter includes an exciter stage and a 2 kw. or 10 kw. power amplifier.

The exciter unit consists of a modulating unit and a frequency multiplier and amplifier unit. The latter feeds into the 2 kw. or 10 kw. power amplifier. One modulating unit can drive two multiplier-amplifier units with the associated power amplifiers. The baseband input is 75 ohms, unbalanced, and the order wire input is 600 ohms or 150 ohms, balanced. The carrier frequency is crystal controlled to within ±0.003%. The exciter equipment is rack-mounted on standard 19-inch racks.

The 2 kw. power amplifier employs a klystron and is air-cooled. Power supplies, associated circuits, and the klystron, are mounted in a single cabinet, 5 feet wide, 3 ft. 3 in. deep, and 7 ft. high. The amplifier is designed for connection to a 50 ohm line through a 3⅛ inch coaxial cable flange. The power load is approximately 9 kva. An air-cooled dummy load is incorporated and a manual coaxial switch is provided for connecting to either the dummy load or the antenna.

The 10 kw. power amplifier is a liquid-cooled unit, the cooling system being separate from the radio equipment. The power supplies, klystron, and other amplifier apparatus are mounted in cabinets installed side-by-side to occupy a space 14 ft. 6 in. wide, 4 ft. deep, and 7 ft. high. The output connection is similar to the 2 kw. amplifier. The power load is approximately 40 kva. A liquid-cooled dummy load is incorporated with a manual coaxial switch to connect the amplifier either to the load or to the antenna.

Diversity Receiver

The diversity receiver unit comprises a conventional super heterodyne receiver, a pre-selector filter and a combiner unit. Four identical diversity receivers are required for quadruple diversity. The combiner outputs are connected in parallel and the contribution of each receiver to the total output is at all times proportional to the signal-to-noise ratio of the individual receiver.

The receiver, including the pre-selector, has a noise figure better than 8 db. The input impedance is 50 ohms unbalanced for connection to a coaxial line, and the base band output is 75 ohms. unbalanced. The diversity receivers are rack-mounted on 19-inch racks.

A unit, incorporating a recording meter, is provided at each receiver installation for the observation and recording of radio transmission. It may be connected to any one of the four receivers.

Antennas and Feed Horns

High gain antennas are required in tropospheric scatter systems. For the frequency band used in this project, the centre-fed parabolie reflector type is most satisfactory. Different antenna gains were required in the several relay sections and, as large antennas are costly, three sizes were provided, the reflectors being 30, 45, and 60 ft. in diameter. The reflector face of the 45-ft. and 60-ft. sizes is a square with the corners removed, and the diameter referred to is that of the inscribed circle. The ratio of antenna diameter to focal length of the parabola was kept constant to permit using the same feed horn design for the three sizes.

Expected gains of the antennas at 800 Mc/s. are as follows:

Reflector Diameter	*Gain with Respect to Isotropic*
60 ft.	41 db
45 ft.	38.5 db
30 ft.	35 db

Further information on the antenna reflector and feed horn support is given later in the paper.

The quadruple diversity plan calls for connecting one transmitter and two receivers to each antenna. Each feed horn must handle signals for a transmitter and receiver on one polarization, and for a receiver on the other polarization. To simplify the filters necessary to separate the transmitter and receiver connected to the same feed horn, the vertically and horizontally polarized signals should be isolated as much as possible.

The feed horn is a square-aperture waveguide horn to handle both horizontally and vertically polarized signals. The signal of one polarization is introduced by a waveguide feed at the rear of the horn. The cross-polarized signal, which is always a receiver signal, is extracted by a secondary feed terminated in a 1⅝-in. coaxial flange on the side of the horn. The isolation between signals of the two polarizations exceeds 35 db.

The face of the horn is closed by a fibre-glass window and the whole unit can be pressurized. A 500-watt heater is built into the rim of the horn for de-icing.

Radio Frequency Transmission Lines

There are two radio frequency transmission lines to each antenna (Fig. 3). One is a common feeder for the transmitter and one of the receivers. The other carries only a receiver signal. Two types of feeders are used, waveguide and coaxial line. The waveguide is WR975, a rectangular type with a 9¾ x 4⅞ in. cross section. The main runs are rigid, but sections of flexible waveguide are introduced at some of the corners to allow tolerance during installation and subsequent movement. The coaxial line is either 1⅝ or 3⅛ in. in diameter. Rigid coaxial line is used to a limited extent inside the buildings. The outdoor runs are all styroflex. Both the waveguide and the coaxial lines are pressurized.

The WR975 waveguide will transmit greater power than the 3⅛ in. coaxial line and also introduces less loss. In the 10 kw. transmitters, waveguide is required to handle the power in the transmitter feeder. The feeders for the 2 kw. transmitters are 3⅛ in. coaxial line, except at Sona Lake where waveguide was specified to avoid air transport of the heavy reels for the coaxial line. The secondary receiver feeders are all coaxial line.

Branching Filters

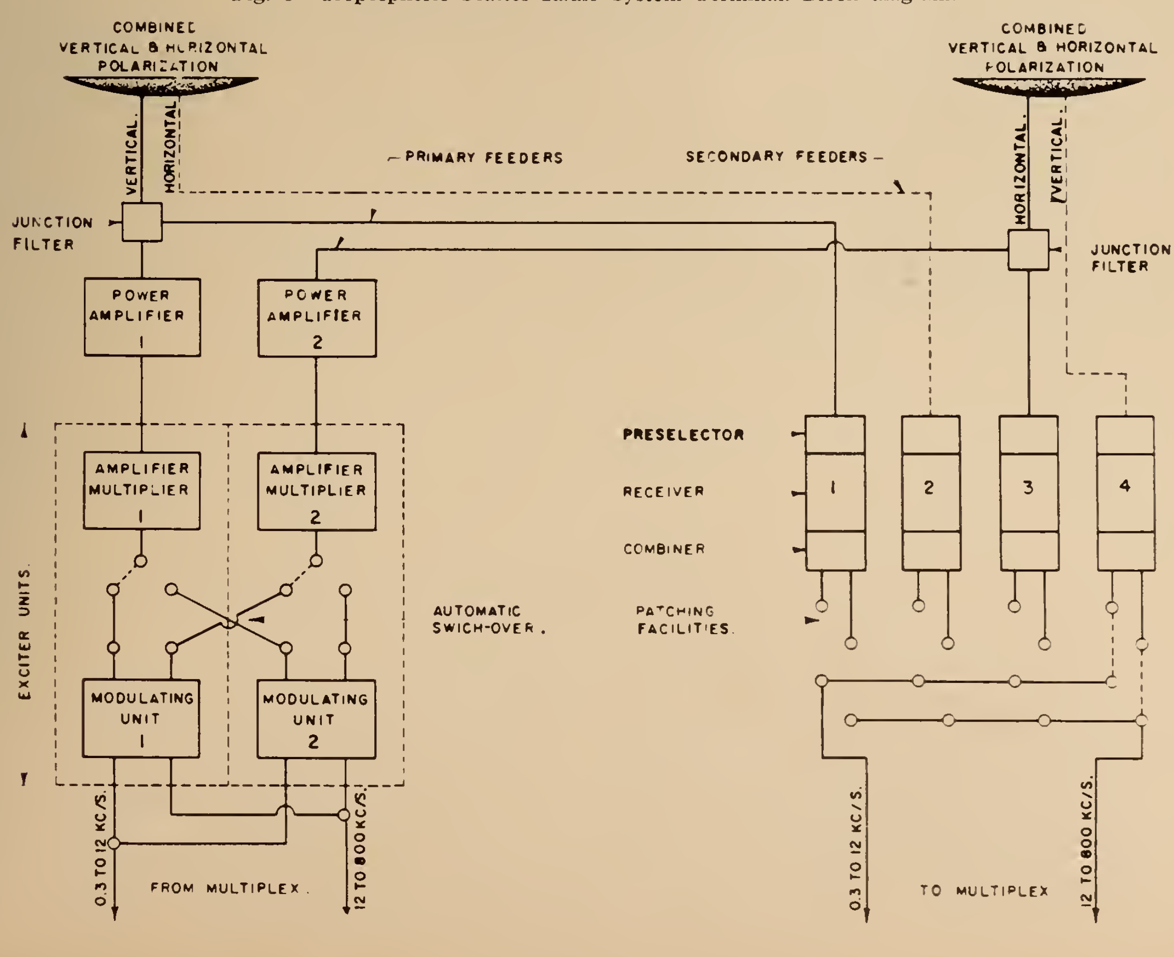
A transmitter and a receiver are connected to the common transmission line feeder through a branching filter (Fig. 3). The filter, in association with the receiver pre-selector filter, must protect the receiver against the high output power of the transmitter, and it must pass both the transmitter and receiver signals without excess loss or other impairment.

The filters consist of an assembly of 3⅛ in. coaxial line units silver-soldered together. The common feeder connects to the stem of a "T". Shorted coaxial stubs are bridged on each arm of the "T" and are adjustable in length to control the filter characteristics of the transmitter and the receiver branches.

Frequency Plan

The selection of frequencies for a multi-hop tropospheric scatter radio system was discussed earlier. Among other requirements, the frequency assignments must be compatible among themselves at each radio station and must also co-ordinate with the frequencies at all other stations where

Fig. 3 Tropospheric Scatter Radio System Terminal. Block diagram.



the receiver power may be sufficient to be a source of interference.

The minimum frequency separations permissible with the equipment installed in this project are: 96 Mc/s. between the transmitter and receiver frequencies in a common antenna; 60 Mc/s. between a transmitter and a receiver operating back-to-back at a relay station; 12 Mc/s. between two transmitters or two receivers operating back-to-back at a relay station.

Figure 4 shows the frequencies authorized for the project. In addition to the restrictions on frequencies within the particular project, the assignments must also co-ordinate with all other radio stations operating in the vicinity. This was of particular importance at Trouble Mountain and Goose Bay where there are many other radio installations.

There are four pairs of frequencies extending from 755 Mc/s. to 887 Mc/s. for the five relay sections. One pair of frequencies is assigned to the two sections, Trouble Mountain to Canatiche, and Sona Lake to Goose Bay.

Multiplex Equipment

The tropospheric scatter radio equipment transmits a broad base band from 12 kc/s. to 800 kc/s. and an order wire base band from 0.5 kc/s. to 12 kc/s., each band being available at all terminals and relay stations. The broad base band is subdivided into telephone channels on a frequency division basis using K and L1 carrier equipment.

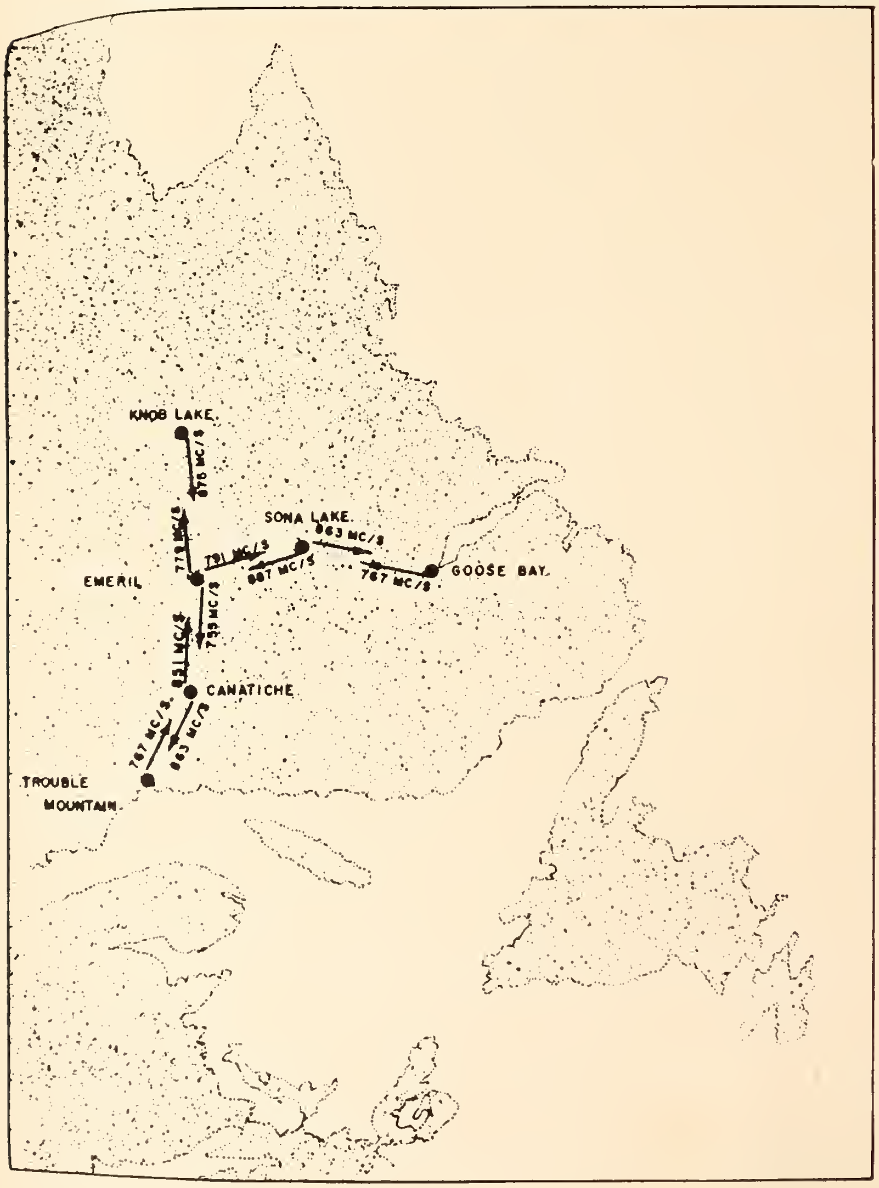
These types of multiplex were chosen for a number of reasons.

(1) The transmission performance objectives for the voice channels were the same as for long-haul circuits in the continental network where K and L carrier are used extensively.

(2) It is proposed to superimpose frequency shift carrier telegraph systems on the voice channels, thereby requiring high stability in the carrier frequency supplies. Provision is made to stabilize the carrier supplies at the several stations by means of a 64 kc/s. pilot transmitted over the system.

(3) L1 carrier is used on the TD-2 part of the overall project, and it facilitates the engineering and the operation and maintenance to extend the same type throughout.

Fig. 4 Frequency assignments: Quebec Labrador Tropospheric Scatter Radio System.



The K carrier equipment provides 12 voice channels in the band from 12 kc/s. to 60 kc/s. The L1 equipment can handle 600 channels, so only part of its capacity is used in this application. In the L1 equipment the voice channels are arranged in group banks of 12 channels each, and combinations of 5 group banks are put together to form super groups.

Super group No. 1 and part of super group No. 2 are being installed initially. These occupy the frequency bands from 68 to 308 kc/s. and from 312 to 552 kc/s.

The number of voice channels being installed initially in the several sections are as shown in Table I.

Table I. Number of Voice Channels Installed Initially

Section	*No. of Voice Channels*	*Type of Multiplex*
Trouble Mt. —Canatiche	108	L1
Canatiche—Emeril	108	L1
Emeril—Knob Lake	36	L1
Emeril—Sona Lake	60	L1
	12	K
Sona Lake —Goose Bay	60	L1

Only those channels necessary for service at the relay stations are brought down to voice frequency. Other channels are connected at carrier frequency to limit the number of conversions from voice to carrier frequency and vice versa. Where a block of 12 or less voice channels are adequate, the K carrier equipment is preferable to the L1 equipment. Initially, it is being installed only in the section from Emeril to Sona Lake.

Additional multiplex channels will be installed later. The critical units, limiting the maximum number of voice channels, are the transmitter power amplifiers in the radio equipment. The specifications called for meeting the performance objectives with 132

Table II. Path Data and Radio Transmission Performance

Site	Horizon Angle min.	Antenna Size ft.	Site	Horizon Angle min.	Antenna Size ft.	Distance Miles	Long Term Mean Path Loss—db	Long Term Median Fading Margin—db
Trouble Mountain	+18	45	Canatiche	−19	45	90.5	186.3	35.2
Canatiche	−22	45	Emeril	−13	45	131.1	186.5	35.0
Emeril	−21	45	Knob Lake	−12	30	118.4	182.4	36.1
Emeril	−13	45	Sona Lake	−12	30	97.0	176.4	42.1
Sona Lake	−10	60	Goose Bay	+23	60	137.4	204.5	30.5

channels on the 2 kw. system and 72 channels on the 10 kw. system. It is believed that realistic objectives are 200 and 100 channels for the 2 kw. and 10 kw. systems, respectively.

System Performance

Table II is a summary of the radio transmission data for each path in the system. In the compilation of the data, the following typical values were used for the various characteristics.

Radio frequency:
800 Mc.
Antenna gains:
60 ft., 40 db above isotropic; 45 ft., 38 db; 30 ft., 35 db above isotropic.
Feeder and filter loss:
10 kw., 2 db; 2 kw., 4 db
Receiver noise figure:
8 db
Receiver I.F. bandwidth:
8 Mc/s.

Primary Power Supply

The reliability of the primary power supply is a critical factor in the continuity of service of a communication system. There was no suitable commercial source of power at any of the troposcatter stations built by the Bell Telephone Company of Canada, so provision had to be made to generate primary power locally at each of them, together with adequate standby. As commercial power is available at the Trouble Mountain station, it was necessary only to install a standby source.

Power is provided at the radio stations by diesel engine alternator sets (Table III). Three sets are installed at each station, any one of which will handle the load. One set normally carries the load, the second is available as emergency back-up, and the third permits maintenance and repair work without interfering with the standby.

Normal operation of the engine alternators and switchover to standby is completely automatic. Remote manual control is also available. Alarms are provided for items such as low oil pressure, low fuel pressure, high water temperature, and overspeed. The alternator output is 208 volts, 3-phase, 4-wire and the normal frequency is 60 cps. As some units in the radio equipment are sensitive to variation in frequency, a monitor is provided to originate an alarm if the frequency varies.

Radio interference from the alternators and associated apparatus is controlled by suppressors and shielded wiring.

The electronic and domestic loads are supplied from separate circuits, protected individually. The circuits may be supplied from different alternators, but normally only one engine alternator set is in operation.

Maintenance of the engines is to be done at the stations. Expendable spares will be kept at each station, and larger spare parts will be stored at one location for the system.

The emergency standby at the Trouble Mountain station is a 60 kw. diesel engine alternator set.

Table III. Diesel Engine-Alternator Installations

Station	Engine Rating, kw. Initially	Supercharged	Alternator Rating, kw.
Canatiche, Emeril, Goose Bay	150	200	200
Knob Lake	100	—	100
Sona Lake	200	225	225

Communication for the Construction Phase

The sites at Canatiche, Emeril, and Sona Lake were not accessible from any commercial communication facilities. Goose Bay could be reached by telegraph but the service was inadequate for the needs of the project. Arrangements were made to serve these locations by a combination of teletype facilities and a private radio telephone network. A teletype circuit was set up from headquarters in Montreal to the construction office in Seven Islands. Private radio telephone stations operating in the medium- and high-frequency bands were established at Seven Islands, Canatiche, Emeril, Sona Lake, and Goose Bay. The transmitters are 100 watts output and all stations are licensed for operation on the same frequencies, 2804 and 5390 kc/s. Communication is point-to-point, messages being relayed verbally at intermediate stations.

Local communication was needed between the Canatiche and Emeril sites and their respective railheads on the Q.N.S. and L. Railway, and between Sona Lake station and the camp site by the lake where aircraft land. The Telephone Company's rural distribution wire laid on the ground or fastened to trees was used for this purpose and proved very satisfactory. At Sona Lake, VHF radio was operated for a period between the lake and the site, together with portable radio sets in the vehicles travelling between the two points, but it was not found necessary to continue this.

All transport to Sona Lake is by air and, to facilitate the operations, an aeronautical beacon station was installed. Since this air transport is in accordance with visual flight regulations, the beacon station was not essential, but its contribution to safety and efficiency warranted the installation. Experience has shown it to be very helpful.

The beacon operates at a frequency of 320 kc/s. and is adjusted for a radiated power output of 25 watts.

Maintenance Procedures

Warning of improper operation and means to carry out maintenance tests and adjustments were prime objectives in the design of the radio system and associated facilities. Alarms report the impairment of performance and the failure of certain components. In some instances, transfer to standby units is automatic in addition to the alarm. Test points allow checking operation while the equipment is in service, and units are readily removable for further investigation and repair.

Two broad guides were followed in planning for maintenance.

(1) All ordinary maintenance tests and repairs should be done without interrupting service. Normally two transmitters are in operation. If one is disabled or out of service for maintenance, the other should be in operation. Diversity is reduced from quadruple to the dual type but service is not interrupted. Similarly, if one or

two receivers are out of service, it is still possible to have dual diversity.

(2) It should be possible to carry out all tests and adjustments at a station without assistance from the adjacent station. Where tests are made in association with the adjacent station, they are to confirm the correctness of adjustment rather than being the condition for determining the adjustment.

Test instruments and other facilities at each station enable the staff to carry out all work required to put the system into service and to maintain it. It is expected that many repairs to units of equipment can be made at the station, though some will require special tools or techniques and will have to be returned to a central repair depot.

One tool which is most useful both in adjusting the radio equipment and in locating trouble is the "loop test set". It provides for extracting a signal from the transmitter, translating it to the receiver frequency, and feeding it into the receiver which operates on the same path. It facilitates adjusting the transmitter deviation and the receiver output level and also permits making noise and intermodulation tests on the equipment at a station.

The power amplifier klystron must be replaced occasionally, and a spare klystron carriage is supplied together with associated tuning coils and cavities. The defective one, together with its carriage, is moved out on casters and the spare substituted.

Essential instructions for operation and adjustment of the many units comprising the radio system, and for the overall line-up and maintenance, have been prepared in the form of Bell System Practices and have also been useful in the training of staff.

Operating experience is needed to establish standard maintenance procedures for equipment as complex as the tropo-scatter system. Some of the procedures are therefore temporary and will be subject to review.

Initial Test and Line-up of the System

The initial test and line up of the system will be carried out by the plant department staff. However, an engineer assigned to each station will advise the plant staff during the whole period. The system must be completely lined up in accordance with the instructions at the beginning. Otherwise, it is almost impossible to adjust it properly afterwards.

At the time of writing, the installation of the electrical and electronic equipment was practically complete and testing was under way. The system has now been through a complete lineup and break-in period and handles commercial telephone service.

Part II. Structural Design, Construction, and Transportation

Part II of this paper deals with the design and execution of the structures, works and buildings, associated with the Quebec-Labrador Tropospheric Scatter System. It is not the application of a recent engineering development, but the story of the adaptation of commonplace crafts and materials to meet an unusual situation.

The task involved the construction of a system of five stations. The system, spanning a distance of more than five hundred air miles traversed rugged northern terrain. The sites, except at Knob Lake and Goose Bay, were in totally uninhabited areas, on the summits of mountains to which there was no established access.

The design programme could not be undertaken prior to January 1957. The committed system service date was June 1, 1958, a period with but one summer season. This, combined with the effects of latitude and altitude, resulted in a construction season free of frost and snow of less than three months at all sites. A substantial part of this season would be taken up, at least at the intermediate stations, constructing access roads from the freight heads to the summits, over which the necessary construction materials could be transported.

Following the initial breakthrough, further time would be required to transport camp materials and to build the main construction camps, before starting work on the permanent structures.

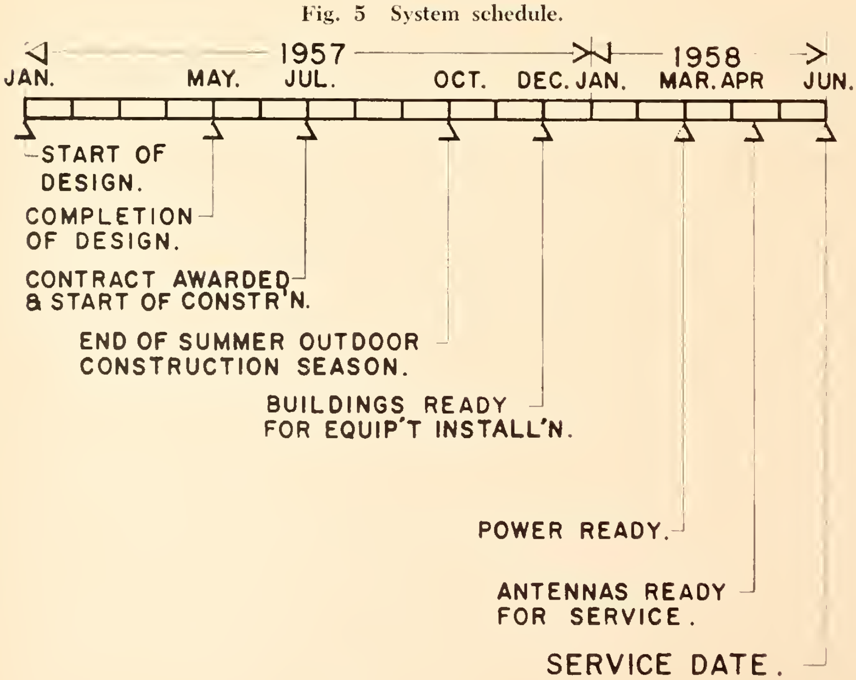
The system schedule (Fig. 5) demanded that the building areas required for the housing of the electronic equipment at all sites be completed, painted out, and dustfree by December 1st, 1957 to meet the start of the installation and test programme.

The situation at Sona Lake was further complicated by the fact that this site is accessible only by air. Preliminary estimates indicated that a gross of 2,500 tons of construction and support materials would be required at each site. The importance of holding this tonnage to a minimum need not be stressed.

The problem could not be resolved by a massive approach, even if such an approach were *economically* feasible. Overstaffing at the outset would result in a disproportionate period being spent constructing camp accommodation, so shortening the productive programme. The compact nature of the plant and the limited area occupied would restrict the number of concurrent work parties. This would preclude offsetting the overshortened construction period by merely adding workers.

Understaffing at the outset would lead to productive staff being diverted belatedly from the permanent works to construct camp accommodation for reinforcements.

Fig. 5 System schedule.



The optimum solution lay in the integration of the design, construction, and transportation concepts. In general, this involved the need to minimize weight commensurate with structural adequacy, and reduction of on-site labour by prefabrication, simplification of detail, and similar means. These ameliorating conditions had to be moderated by the realization that obvious advantages of prefabrication might be offset by less obvious disadvantages of prefab assemblies, difficult and expensive to transport, or requiring the transportation of small crews of specialist erectors or assemblers. It required full exploitation of work simplification and short cuts to intermediate programme objectives provided in the design, even if this meant digression from trade habit. Finally, one had to recognize the critical but basically ancillary role of transportation. The plan as visualized must be of adequate capacity, capable of immediate response to change of job pace and organizationally susceptible to such demands. It must have built-in deterrents to the tendency of project transportation organizations to become autonomous and to pursue their local efficiencies to the overall cost of the project.

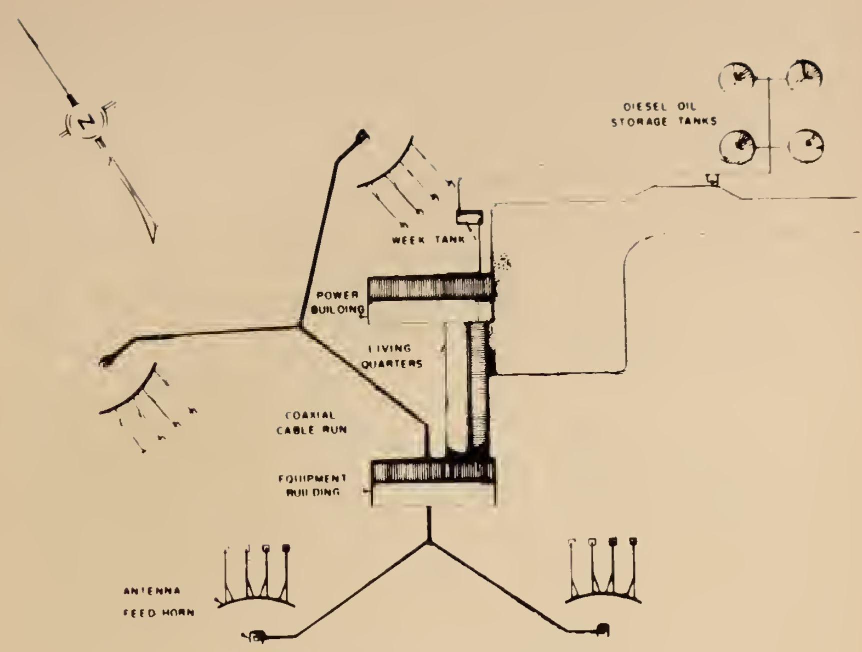


Fig. 6 Plan of the general layout.

DESIGN

The principal structural components required at each site were the buildings, the parabolic antennas, and the petroleum product storage facilities. A basic building design consideration in northern latitudes is whether related facilities are to be grouped under one roof, and closed in by one building form, or whether an open plan providing each separate facility with its own building may prove more advantageous.

In this instance four distinct main areas were: the radio equipment area, the diesel generator power room, the operators' living accommodation, and the garage.

The electronic equipment floor area requirement ranged from 1800 sq. ft. at the terminal sites to 2500 sq. ft. at the relay sites.

The power requirements also varied from station to station, from 100 kw. to 200 kw. However, the effect of this on floor space tended to become imperceptible.

With the electronic equipment and power room areas established, it was now possible to turn to consideration of the living accommodation areas.

The resident operating crew was set at seven, including the cook and houseman for the isolated stations at Emeril, Canatiche, and Sona Lake. To this number would be added any permanent personnel required to operate the heating plant, water and sewer facilities, the petroleum product installation, and similar services. Such personnel would increase the service facility requirement with a commensurate increase in support labour. A compact and highly mechanized plant requiring no additional personnel was indicated to offset the increase of support costs once the minimum personnel were exceeded.

A single roof design would eliminate interbuilding corridors, essential in such exposed locations; would simplify the water and sewer systems; and even more important, would present the possibility of meeting all heating requirements by recovering heat from the electronic equipment and the diesel generators.

A single floor plan was developed. Consideration of all factors led to it taking the form of a square U with the electronic equipment housed in one wing, the diesel generator room, water storage, and garage in the second wing, and the living accommodation area forming the base or tying member (Fig. 6).

Previous experience at exposed locations of comparable latitude had established the need to design against 120 m.p.h. winds, 90 lb. snow loads, and a temperature range from 40° to +90°F.

The system will be operated by personnel drawn, in rotation, from the Company's standing staff. These people have predominantly urban backgrounds, and provision must be made against mental as well as physical discomforts of living on a mountain top, confronted with the seemingly endless and empty wastes of the northland. This situation was met by developing the interior of the living accommodation wing along familiar and homelike lines. The basic floor plan was built around the customary living room, dining room, and kitchen core with bedrooms arranged bungalow-style along a central corridor.

With the floor plan developed and dimensioned, available prefabricated buildings could be studied and a choice made. A commercially-available stressed skin prefab was selected for all buildings required for the system.

Building Foundations

The building foundation design was controlled by the very short construction period available, the general lack of suitable aggregate, the need to hold weight down in view of the high transport costs, and the fact that all the buildings were founded on rock.

A free-standing wood post and laminated beam foundation was used under the equipment and living accommodation areas. The wing housing the generator room and garage was set on a concrete perimeter wall. A conventional reinforced concrete structural slab and girder floor was used in the diesel room. Individual concrete piers were provided for each generator unit. These piers were founded on rock, carried up through, and held free of the floor slab on fill.

Floors

Laminated wood floors were used in the equipment wing. The structure was designed to meet a uniform distributed load of 150 lb./sq. ft.

Principal factors contributing to the choice of this form of foundation and floor structure were:

(1) It is speedily erected of readily available and transportable materials.

(2) It does not require specialist labour.

(3) Construction is relatively independent of weather conditions.

(4) It can be held to minimum dimensions and weight as any future change in concentrated load can be met readily, without interior disturbance, by merely increasing the underpinning.

(5) It does not require the use of any equipment other than hand tools.

(6) It has a "U" factor of approximately 0.1.

An insulated wood beam and plywood deck floor was used for the living quarters. All lumber used in the foundation and floor systems was pressure-treated against rot. Its "U" factor was computed as approximately 0.1.

As previously mentioned, concrete slab floors were used in the diesel generator-garage wing as the schedule permitted a few weeks additional time for its construction. The advantages of this stronger, more permanent and fire-resistive construction for this application outweighed the additional cost and effort.

A four-thousand gallon reinforced concrete water storage tank was located in one corner of the diesel room. Founded on rock, it was carried up through the slab to a height of 3 ft. above floor level. The tank top formed a low mezzanine on which the station supervisor's office was constructed. Also by this means an area of the tank walls was exposed to the warm diesel room atmosphere as a precaution against freezing of the stored water.

Interior Finish

In keeping with the design approach previously mentioned, selection of materials for the interior finishing of the living accommodation wing was limited to those commonly used in medium range residential building. The kitchen, partially open to view from the dining area, is a slightly oversize version of the familiar planned kitchen encountered in such residences. Although presided over by a professional cook, it has none of the trappings usually associated with commercial or institutional kitchens. Individual colour schemes were developed for each room. Good quality domestic furniture, in harmony with the colour scheme, contributed to a cheerful, familiar and homelike atmosphere. The use of colour was extended to the work areas to offset monotony. Windows were generously proportioned and placed to take advantage of the vast outdoor panorama.

The windows were designed with a fixed sash and a permanently screened and louvered full-width opening immediately above the sill. This opening was closed on the inner face with an insulated gasketted hinged panel. This panel, closed, provides an insulated seal, and in its open or ventilating position acts as a draft deflector.

The windows, also designed by the owners' staff, were readily fabricated. They are draft free, do not require additional screens or storm sash, and remain frost free. This relieves the sense of claustrophobia which might otherwise be generated.

Conventional hardware was used throughout except on the exterior doors. These were fitted with bakelite handles to prevent damp hands freezing to them and shaped to provide a good grip for heavily-mittened users.

Heating and Ventilating

With the building design fairly well determined, maximum losses were computed and found to be 415,000 B.t.u. per hour under the most severe conditions expected. This, when combined with the ventilation requirements and the heat loss occasioned by drawing the diesel aspiration air directly into the power room, totalled less than the amount of heat which could be recovered from the electronic equipment and the diesel generators. This confirmed the feasibility of heating entirely by recovered heat and the practicality of a one-roof design. Detailed design on this basis could now proceed.

Principal considerations in the design of the heating, cooling and ventilating systems were:

(1) To provide adequate cooling systems for the operating elements, both mechanical and electrical.

(2) To ensure that individuality of unit cooling systems be maintained against the possibility of backup loss by the failure of a common element in the cooling system.

(3) To recover sufficient heat to meet all heating requirements.

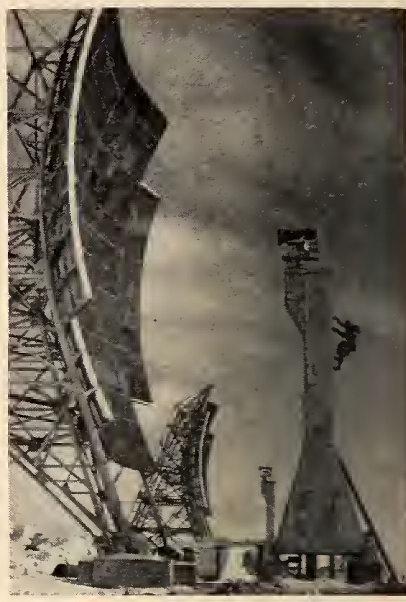


Fig. 7 View of the antenna and feed horn structures.

(4) To provide adequate ventilation.

To do this, two separate heat exchange plenum chambers were provided near the equipment requiring cooling; one in the power wing and one in the equipment wing.

The electronic equipment uses about 25% of the energy input; the difference is dissipated as heat. The greatest energy loss associated with this equipment is concentrated in the klystron units. The 10-kw. output klystrons with their 40 kw. input utilize both air and liquid cooling. The 2-kw. output units are air cooled and dissipate their heat directly to the room. The diesel generators provide the only other source of heat and are liquid-cooled.

The heat dissipated by the klystron blower systems is collected by large exhaust hoods covering the area occupied by the klystrons. This heat is ducted to a plenum chamber located in the equipment wing heat exchange room. Liquid cooling of the klystrons is by circulating a 50-50 solution of ethylene glycol and water through the body and collector of the klystron tube to a heat exchange coil in the plenum chamber. Each klystron is served by a completely separate pump, piping, and heat exchange coil, and is therefore independent of failure of its neighbour.

The diesel generator liquid cooling systems are similarly arranged. Each unit is connected by a separate piping system to individual remote radiators located in a common plenum chamber at the end of the power room.

With the heat largely concentrated in the two plenum chambers, it could be quite readily used or dissipated.

Four distinct duct systems were developed which permitted transfer of heated air from the power room plenum chamber to the power wing, the garage and the living quarters. Use of the heat recovered from the electronic equipment was limited to the heating of the equipment wing.

Ventilation of the power room is provided in summer by manually-operated propeller fans in the outside walls discharging directly to atmosphere. Power room comfort is maintained by these fans which provide 25 air changes per hour.

The equipment wing is ventilated in summer by a series of modulating dampers, bypasses, and thermostats which introduce outside air into the duct system, while exhausting the heated air from the heat exchange to outdoors. By this means equipment room temperatures can be held to within 12 degrees of outside ambient. All systems have humidifiers, smoke alarms, and controls for automatic heating and ventilation of the building areas as well as the cooling of the electronic equipment and diesel generators.

All sites are equipped with an automatic fire detection system.

As the stations will be attended continuously, fire-fighting will be manual. Each wing is equipped with portable CO_2 extinguishers, supplemented by a bulk supply of CO_2 stored in the garage in 50-lb. cylinders. These cylinders are manifolded together and fitted with a spray-nozzled 150-ft. hose that can reach all parts of the building.

Survival Huts

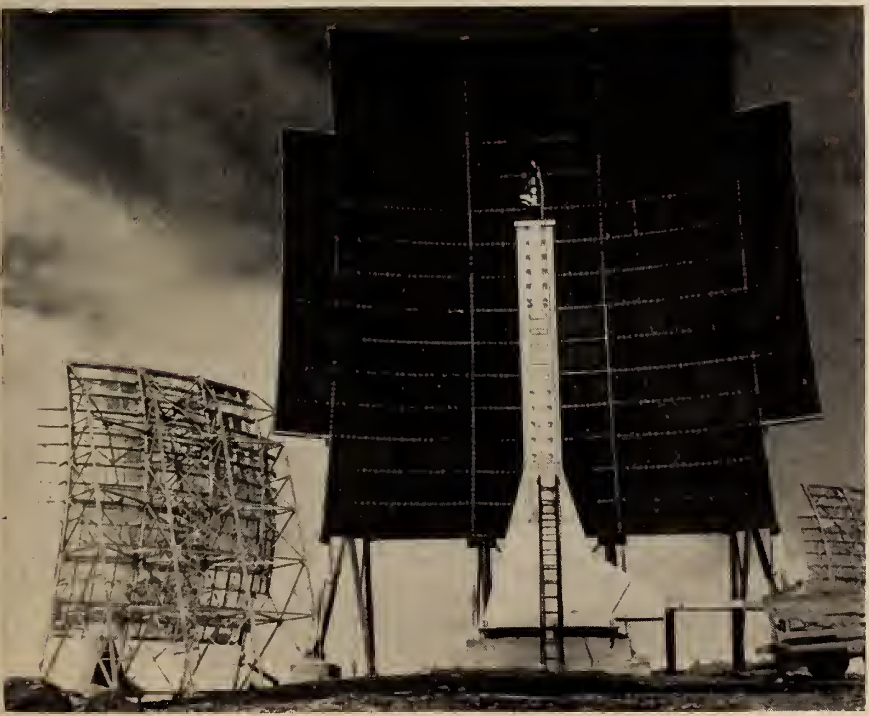
The buildings were made as fire-resistive as was economically feasible under the difficult conditions. However, they are not fireproof. Survival huts were built and equipped at each of the remote locations to afford shelter to a burnt-out crew until help could arrive. These insulated huts, of light wood and plywood construction, are completely fitted out with heaters, beds, cooking facilities, a small dining area, emergency food storage, and a small electrical generating set to supply electric light and power to operate an emergency radio.

In addition to their role as survival huts, they will be used to accommodate visitors, road and building maintenance, transport crews or other personnel on site for short periods.

Sewers and Water

Insulated septic tanks were used to dispose of sewage. The connecting sewers were spiral wrapped with electric heating wires and insulated to prevent freezing. These systems were all located in rock. Effluent disposal beds were created from backfill blanketed with moss. The disposal piping is not heated.

Fig. 8 Another view of the antenna and feed horn.



The rocky summits on which the relay stations are located have no readily available source of fresh water. Small ponds occurred at Canatiche and Sona Lake some 1500 ft. from the station and about 75 ft. below the summits. At Emeril a shallow well developed during construction at about the same relative position gives promise of meeting the station needs.

The water is carried from pump houses at the sources through electrically-heated piping to the 4,000-gallon inside storage tank previously mentioned. This piping is installed on the surface in insulated troughs. Automatic chlorination was incorporated in all systems.

Antennas

The next major structural components to be considered were the antennas. These were designed against the following conditions. Wind 120 m.p.h. with 3 in. radial deposit of ice; ambient temperature range -60°F. to 100°F. plus sun effect. Maximum permissible deviations under no-load conditions were set at $\pm \frac{1}{2}$ in. over the entire surface within the nominal diameter as measured from the focal point, but not to apply to small projections such as bolt heads.

It was further stipulated that maximum deflections be held to meet the most severe of the following conditions: (a) ± one inch to vertex with 100 m.p.h. wind and one inch radial deposit of ice; (b) ± two inches to lip with 120 m.p.h. wind with no ice. Under maximum load conditions of 120 m.p.h. wind and 3 in. radial deposit of ice, maximum developed stresses were not to exceed the elastic limit.

Antennas of 60, 45, and 30 ft. diameter were required. The 30 ft. size was available with modifications as a shelf item. The larger antennas required a different approach. Previous experience had indicated the desirability of designing large diameter antennas, for use under the severe conditions outlined, to transmit loads as directly as possible to the foundations. It is also considered advisable to utilize standard steel sections, conventional shop fabrication procedures, and drive-bolted field connections. Deflections of the antenna structure are more readily controlled if the feed horn is designed as a separate free-standing structure.

The design was successfully developed along these lines by Mr. Brian

R. Perry and his associates, Montreal consulting engineers, who also designed the foundations for the antennas.

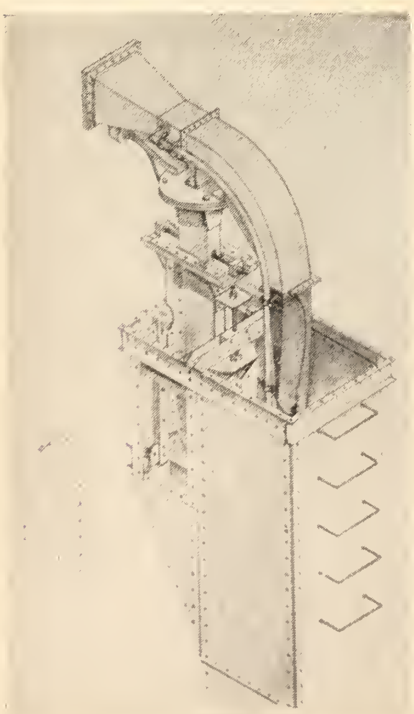
The fact that the traces of planes intersecting a paraboloid, and parallel to its axis, are themselves parabolic and mathematically identical regardless of their location on the paraboloid, permitted the use of essentially duplicate vertical trusses. This approach resulted in a satisfactory structure meeting all requirements and with the added virtue of great simplicity (Fig. 7).

The rectilinear shape of the structural backup also contributed to a ready means of checking the accuracy of the antenna surface in that it provided definite points to which the cartesian co-ordinates of surface check points could be referred.

The antenna surfaces were fabricated from 16-gauge galvanized steel plate bolted to the frame with ⅜ in. bolts on approximately 6 in. centres (Fig. 8).

Due to the weight of the structures and the multiple trusses, it was not considered practical to provide means of altering the orientation of the antenna. Nevertheless, ability to rotate the beam within a moderate range was desirable, not only to offset possible errors in orientation, but also to select the position for optimum transmission.

Fig. 9 Isometric view of feed horn tower.



The sweep required could be accomplished by varying the position of the feed horn (Fig. 9) 12 in. left or right of the horizontal axis, by tilting the entire feed horn tower about its base centre line. The base was provided with a simple jack screw and hinge mechanism. In addition the feed horn support was mounted on lead screws by which it could be adjusted ±6 in. along the axis of the antenna, with a similar arrangement for vertical adjustment.

Antenna and Feed Horn Foundations

All the antennas would be founded on rock. The foundations were individual concrete footings anchored into the rock for each of the vertical truss legs. The mass of these footings was the minimum necessary to transfer load from the anchor bolt assemblies to the rock anchor system, as bearing was not a controlling factor.

Fuel Supply

Since the power at all sites is provided by diesel-driven units, this necessitates an adequate supply of diesel fuel. Additionally there is the requirement for gasoline for vehicles and other mechanical equipment.

Principal considerations in the design of the fuel supply systems were: (1) type of fuel; (2) method of supply; (3) unloading facilities; (4) storage facilities; (5) on-site pumping and fuel handling facilities; (6) piping design.

Salient factors in the selection of the fuel were a low pour-point and low sulphur content. Type 1 Arctic Diesel with a pour point of -45°F. and maximum sulphur content of 1.0% was selected.

A commercial supply of fuel is available at Knob Lake and Goose Bay. Here no unloading facilities have been provided. The obvious means of supplying Canatiche and Emeril was the Quebec North Shore and Labrador Railway.

The trackside facilities are designed to unload one to three 10,000-gal. tank cars at one time without shunting or relocating the cars. A 25,000-gal. storage tank at each siding avoided the undesirable practice of unloading directly from tank car to tank truck and to overcome delay in car unloadings due to interruption of the truck haul.

The pumps are permanently piped and so connected that by operation of the valves they can be readily used either to unload from rail or airborne tankers or to load the tank vehicles used to transport to the summits.

Three sizes of tanks with the following characteristics were decided upon.

(1) Field fabricated 25,000 I.g. vertical tanks 20 ft. dia. by 12 ft. high.

(2) Prefabricated 5,000 I.g. horizontal tanks 8 ft. dia. by 15 ft. 6 in. long.

(3) Prefabricated 1,000 I.g. horizontal tanks 4 ft. 8 in. dia. by 9 ft. 10 in. long.

Tank farms were provided at each of the relay sites. These have a storage capacity of approximately 125,000 gal. per site, sufficient to carry the station for a year with safety.

To reduce maintenance, the pipe layout was designed to provide ample flexibility for all pipe movements without the use of flexible joints or couplings, and to provide maximum accessibility during inclement weather consistent with acceptable and economic piping practice. Precautions taken to minimize the hazard of losses due to pipe damage included the use of vacuum breakers and foot valves.

Site Layouts

With the number and dimensions of the major structural components determined, it was possible to develop the detailed site layouts. These were required by the start of construction as their relative positions are quite important.

The electronic criteria relating to the development of the site layout stipulated:

(1) A separation of 200 ft. between the axis of antennas facing in the same direction.

(2) The waveguides or styroflex lead-ins for a pair of antennas to be of the same length and not longer than 300 ft. from their respective feed horns to entry to the equipment building.

(3) Buildings and structures to be kept clear of the antenna foreground areas covered by a horizontal angle of 30° to the left or right of the vertical outer edges of the antenna reflectors.

In addition to the above, the location of the approach roads and their entrance to the site were governed by the electrical characteristics of the system.

To avoid signal interference by

vehicle ignition systems, the approach roads had to traverse the area overshot by the beams below a plane through the lower rim of the antennas, and inclined at an angle 10° below the horizontal.

Further, the roads were prohibited from areas in which the exposure to radiations from the antennas would exceed an intensity in excess of one milliwatt/sq. cm. There are indications that higher exposures may prove harmful to life.

The Canatiche and Emeril station sites were selected by office studies during the winter of 1956-57. Field information was limited to that procured by the siting party during brief visits and was of reconnaissance survey order. Nevertheless, the development of site plans could not be further delayed.

An aerial inspection by light aircraft flying at low altitude, was made to select the most likely routes for access roads to the Emeril and Canatiche stations in early 1957. Various possibilities were further investigated by walking over the selected routes, establishing traverses, securing some spot levels and notes on the topography.

Rough contour plans were prepared from this information, supplemented by data from maps and aerial photographs, and the usual computations associated with the estimating of road construction were made. As it was anticipated that the work would be done under a form of owner-managed cost-plus contract, it was considered that these methods would produce results of adequate accuracy.

CONSTRUCTION

The individual stations differ widely in ease of access and other factors affecting the task involved in their construction. Nevertheless, progress must be adjusted to overcome these variations, so that all reach the same state by the first fixed dates in the system schedule.

This frequently requires a distortion of the normal sequence of work, and contract arrangements must respect this fact.

The purchase of materials must be coordinated to secure desired system standardization, particularly of electrical and mechanical items, without undue resort to the closed specification.

Overall policies relative to wages and working conditions must avoid differences between neighbouring divisions of the work, which may cause discontent and high labour turnover.

A consolidated transportation control must be organized with facilities available to all elements, particularly in areas served only by chartered transport facilities. If expensive job delays are to be avoided, this transportation setup must be under the complete control of the organization directly responsible for field progress.

The best types of contract for the services of the various contractors must be selected, and the degree of direct control which the owner wishes to retain must be determined and organized.

Although the programme required that the system be ready for service by June 1, 1958, necessary test and lineup periods following the electronic equipment installation established secondary but critical intermediate points in the schedule. These required that: (a) the equipment areas be completed ready for the start of electronic equipment installation by December 1, 1957; (b) the station power plants be ready to deliver power at full operational level by March 1, 1958; (c) the antennas, feed horns, and waveguide installations be ready for full operational test by April 15, 1958.

May 1st was the earliest date by which the design programme could be completed and specifications prepared. From experience, July 1st was the earliest date for major work on the access roads following the spring breakup, and contracts must be awarded in time to start work by that date. Materials to be ordered by the general contractors must therefore be limited to those readily available. Consequently, all elements which required specific manufacture were listed from advance working drawings. To this list were added any items which were to be standard throughout the system.

Materials so identified were procured directly by the owners and issued to the job. They included the building shells, the antennas, feed horn towers and feed horns, waveguides, petroleum tanks, fans, motors, and controls for the heating and ventilating system.

The contracts for the erection of the antennas and the fuel oil tanks were arranged and administered directly by the owners. Issue items were listed in the tender calls to construction contractors, who were required to carry out the quantity surveys and purchase all other materials necessary for the construction work.

By this division of work, materials were made available in time, the desired degree of standardization was achieved, and the talents of the general contractor's staff were brought to bear at the earliest opportunity.

General policies relative to on-site pay and working conditions, developed to avoid disparity between sites, were set out in the tender calls. It was recognized that, if the labour response proved inadequate, they would have to be adjusted.

General Contract Arrangements

Unpredictable elements, which might seriously affect cost, prohibited the use of fixed price contracts. Detailed plans and specifications of the structures involved were available in time to tender. It was considered that these, plus an approximate delineation of the on-site freight handling and roadwork, provided sufficient information on which to base competitive tenders on a cost plus fixed fee basis. Competitive elements included the fee, offsite overhead, and the equipment rental rates. Responses were well grouped and highly competitive, confirming the feasibility of the method of tendering. The invitations to tender described fully the extent of owner management under which the work was to be executed.

Isolation pay or special incentive pay other than that inherent in the sixty-hour work week was not offered. No difficulty was encountered by the contractors when recruiting labour, although it was found necessary to offer a 70-hour week to steel erectors. An extremely small proportion rejected employment when informed of the dry rule, but the employers considered that the job gained more than it lost by these rejections.

Sona Lake

Sona Lake provided the only exception to the contract arrangements outlined above. The construction of this station depended entirely on transportation by aircraft. The station is on a mountain-top approximately four miles from the shoreline of the lake. The surrounding area is broken by ridges interspersed with extensive swamps and boulder fields. It is devoid of eskers or other fortuitous deposits suitable for the construction of a temporary airstrip. The lake presents the only feasible landing area.

The largest amphibious aircraft commercially available in Canada is the Canso. The largest commercially available aircraft which can be equipped with skis and landed on an unprepared area is the DC3, and study indicated it would be feasible to land this aircraft on the frozen lake. With the equipment which could be transported by DC3, an ice strip capable of accommodating larger freight planes, limited to wheeled landings, might be developed on the lake.

In view of the more economical rates and greater bulk capacities of the wheeled aircraft, which would largely obviate dismantling the construction equipment and diesel generators, it was decided to carry out an advance winter airlift during the late winter and spring of 1957.

A detailed plan for the construction of the site was developed by the owners from advance drawings and data available from previous projects. This included estimates of labour, camp size, construction equipment, fuel, diesel oil and gasoline requirement, food, camp supplies, and construction materials. In this instance, and in the absence of plans and specifications on which competitive tendering could be based, a contract was arranged with a selected contractor on a cost plus basis.

An advance party made up largely of contractor's personnel under the control of a Company transport foreman was sent to the site in early February. A small camp was established on shore at the proposed origin of the access road. A radio beacon was installed and a freight marshalling area cleared. A miniature bulldozer and jeep left on site by a previous engineering exploration party had been purchased and were used to assist in clearing a preliminary ice strip. Support of this partv was initially by the ski-equipped DC3. With the snow blanket removed, the ice thickness increased steadily until by early March the 34 in. required to land C46 aircraft was reached. It was not expected that the ice thickness would last beyond April 1st. A shortage of C46 aircraft and mild weather which flooded the airstrip, further reduced the transportation by heavy aircraft. However, with the assistance of the radio beacon and temporary strip lighting, round the clock flying was possible during good weather. The contractor's equipment, one of the permanent diesel generators, muskeg tractors, sections of the antennas, and fuel tanks too large to be transported by Canso were moved in first. With this accomplished, the programme was assured. However, heavy aircraft flying was continued as late as possible to take full advantage of the economies.

The entire air operation was carried out with but one mishap. This involved a C46 aircraft, carrying a six-ton tractor, which landed on the ice strip April 6th with its undercarriage up. The aircraft lost its propellers, air intakes, and other parts. The tractor stayed put, testimony to the efficiency of the transport group, and the crew were unhurt. The air operator was in a less happy position, but the entire construction party worked shift to jack the aircraft and make ready for the salvage party. This party arrived April 9th with necessary replacement parts, and the aircraft took off April 13, seven days after the accident.

By April 28th the ice had thinned until it would no longer support heavy aircraft landings. However, contact with the advance party was maintained with light ski-equipped aircraft until May 22nd. From then to June 9th when the first water landing was made, the advance party of twenty-four men was isolated.

It had been hoped to establish a winter tote road to the summit, transport the freight on hand, and establish the main construction camp. However, despite the use of muskeg tractors, the attempt was abandoned. Consequently the advance party limited their efforts during the spring period to improving the lake camp, the marshalling area, building a motor vehicle repair shelter, and generally getting ready for the summer operation. By the time the snow was gone, the Sona Lake programme was advanced sufficiently to keep pace with the other stations and maintain schedule.

A total of 500 tons was moved in during March and April. The heaviest lift was a 6-ton tractor. All material lifted during this operation was transported to Seven Islands by the north shore route and flown in from there.

Access Roads

It was proposed to bring the permanent roads only to "carriageable" grade of single pass width as their use would be limited to the domestic traffic of the permanent operating crew of seven plus the annual transportation of approximately 125,000 gal. of oil. The operational plan further contemplated equipping the stations with muskeg tractors and trailers to handle essential traffic during spring breakup and in winter when it might prove impractical to keep the roads plowed. Nevertheless, the start of transportation of materials to the summits, the establishment of construction camps, and the start of work on the stations proper could not be delayed until the access roads had been built. With about 12 weeks available before severe winter weather and 20 weeks before the electronic equipment areas must be ready for the installation programme, it was essential that tote roads be cut through to the sites at the summits as quickly as possible. Construction of the permanent roads would be carried on concurrently.

Summer Construction 1957

The tote roads were traversable only by tracked vehicles. Stone boats and heavy duty farm wagons were used as tows. However, platform-equipped heavy duty logging sleighs proved the most sucessful tow over the wet soil conditions encountered. A D4 tractor or equivalent towing such a sleigh could handle a six-ton load over the tote roads at an average speed of about two miles per hour. Winching was resorted to when required to overcome the typical sharp pitch to the summit. The tote roads, because of the high humus overburden and the light nature of the subsoil, cut through after relatively little use. Corduroying crews were kept busy continuously repairing the softer spots, but eventually sections had to be abandoned and bypassing sections made ready. The crews became expert at anticipating such spots and usually the bypass was located, cleared, and at least approaching readiness by the time the worn out section became impassable to freight.

Rock excavation and drilling equipment had been transported to the summits at the earliest possible date to prepare the foundation areas. Next, aggregate for the foundations (500 to 700 tons per site) was hauled distances of from four to seven miles. At times around-the-clock transport was needed to keep sufficient materials ahead of the construction crews. As the permanent roads advanced and could be used the slower tracked-vehicle haul was shortened.

With freight access and camps established on site, an effort was made to construct all foundations practically concurrently, as this was necessary if the concrete work was to be completed before cold weather set in. This work was dominated by the need to achieve an accurate orientation of the antennas and to maintain the relative positions of the other structures.

A relatively rainy summer hindered hauling aggregates over the tote roads, and the exterior concrete programme was not achieved. However, by freezeup in early October all major concrete work had been completed. Final small items such as pump bases and septic tanks were poured by early November. The usual devices of heated aggregates, tarpaulins, and hot air heaters provided all the protection required for this miscellaneous work. No extensive heated hoarding was needed.

The advance anticipated in the erection of the equipment wings with timber foundations and floors was realized.

The shells for the equipment wings were fully erected, the buildings closed in and interior work well in hand by the time the foundation work for the diesel wing was completed. Results varied slightly from site to site. However, by November 1st or approximately two weeks after the onset of severe winter weather, the shells of all buildings had been erected and closed in. The equipment wings at all sites were completed ready for the start of the electronic equipment installation programme by December 1, approximately twelve weeks from the start of construction.

The bases for the petroleum tanks had been made ready by the general contractors concurrently with the early foundation work and the steel plate transported to the sites in readiness for the erection crews. These tanks were assembled by field welding in the usual way. A travelling crew of nine men started the tank erection September 10th and completed the task, including testing, by the end of October. Associated pump, piping and electrical work was carried out by the general contractors.

Antenna Erection

The antenna erection crews were brought in during October. Erection was carried out concurrently at all sites. A typical erection crew comprised a foreman, a lead hand and ten erectors. All steel had been laid out on site before arrival of the erection crews. A mechanical crane was available at Goose Bay, but at all other sites a gin pole was used. Erection was unavoidably over the period from November until mid-February. Some of the winter's most severe weather occurred during this period. Temperatures dropped as low as -40°F, strong winds were fairly constant. Despite this a seven-day work week was maintained by all erection crews. The total lost time due to weather was less than 2%, and there was not a single lost time accident. The twenty antennas required for the system with their associated feed horn towers weighed 840 tons and included 26,808 structural members.

Construction of permanent roads was retarded by freight moving over them. Attempts to minimize this by parallelling tote roads were generally not feasible.

The construction of the Canatiche road proved much easier than had been anticipated. By the end of August a passable truck road had been constructed to about half a mile from the summit. Although the last half mile was the toughest, the prospect of easy truck access was tempting. It was decided to complete the road and let the construction materials accumulate at the rail side.

By September 23, with nine weeks to complete the equipment building, and the truck road still 2,000 feet short, work on the permanent road had to be suspended and toting resumed. Round the clock shift work was instituted to offset the time lost. The "building ready" date was barely met, with difficulty. This was the only, apparently more logical, attempt to build the access road first.

At Emeril, the ten miles of road had been corduroyed and the base laid by freezeup. However, about two feet of gravel was required to bring it to grade. It was expected that winter conditions would stop the work, but the gravel proved relatively dry and workable for the required period.

The road built under these conditions might well prove impassable during the spring thaw but this did not occur. It is not suggested that winter is the best time to build roads in comparable areas, but in this instance it proved practical.

The Sona Lake reconnaisance party found evidence indicating extensive gravel deposits, typical of this area. Construction equipment was scaled to meet this indication. However, it was later discovered that the showing was merely a minor pocket, and the entire area traversed by the road was otherwise devoid of gravel. A substantial deposit, three miles across the lake, could not be linked by road.

A raft was constructed from oil drums and powered with outboard motors. A 5-ton loader was transported across the lake to the gravel deposit, and about 600 tons of aggregate were ferried over during the summer. This was sufficient for all concrete work. The access road was corduroyed and ballasted with the fine sand available until freighting with tracked vehicles was possible. The construction of the station proceeded on schedule.

An ice road was opened across the lake during the following winter and 8000 yd. of gravel were hauled and stockpiled. There were too few trucks to carry on road construction during the winter, although no difficulty was experienced handling the gravel.

The contractors' heavy equipment was removed in April as the 1958 heavy airlift drew to a close. Distribution of gravel and final road grading was carried out by a small work party during the following summer, using equipment permanently assigned to the site for road maintenance.

At May 21, 1958, less than eleven months after the start of construction, the entire project was essentially completed; electronic equipment was installed and tested. The total force engaged on the construction and transportation work built up from zero in early July 1957 to a peak of six hundred (September 15th to October 15th), and then fell steadily to four hundred by January 15, 1958, when an even sharper decline began. At May 1958 less than one hundred were engaged dismantling camps, removing construction equipment, and clearing up minor tasks. All intermediate dates as well as the final dates of the construction schedule were met. Approximately 12,000 tons of material were marshalled and transported to the sites by rail, sea, and air. Air transportation cost over $600,000. Despite site-to-site variations from estimated, the cost of the construction and transportation programme should aggregate approximately one per cent less than the owners' original estimate.

ACKNOWLEDGMENT

The project proved a complex one which demanded the talents of many people. The authors welcome this opportunity to acknowledge the contributions made by their associates.

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DEAS ISLAND TUNNEL

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INTRODUCTION

by Per Hall, P.Eng., M.E.I.C

THE DEAS ISLAND Tunnel, a four-lane vehicular traffic facility, is now under construction near Vancouver for the British Columbia Toll Highways and Bridges Authority. The tunnel will provide a second, urgently needed, permanent crossing of the Fraser River and will form part of a major new freeway-type radial highway emanating southward from Canada's western seaport.

This crossing (Fig. 1) will open the way for the southerly expansion of the metropolitan area which, until now, has been channelled to the east between the two water barriers of Burrard Inlet and the Fraser River. It will augment the capacity of the existing Pattullo Bridge at New Westminster which has already become overtaxed, and will replace the present inadequate ferry service operating to Ladner, B.C. Complementing a new vehicular route the crossing will open large areas of land for residential and industrial development by offering fast, safe transit into and out of Vancouver.

In 1903 the first permanent crossing of the Fraser was established with the construction of a combined highway-railway bridge at New Westminster. Then in 1912 a ferry service was introduced at Ladner, instead of the bridge requested by a Delta Municipality citizens group. By 1925 the New Westminster crossing was inadequate for the traffic requirements and the Government took steps to ensure the future development of routes. As a result a private company undertook the construction of a bridge at Deas Island in 1933. This venture failed in that same year, and it was not until 1937 that the first new crossing, the Pattullo Bridge, opened to replace the highway portion of the New Westminster span.

By 1953, the Pattullo Bridge, purported to be capable of handling 3,000 vehicles an hour in one direction, was obviously near saturation. At this time, studies were initiated to determine the future need for highways and crossings. The resulting report recognized the overtaxing of existing facilities and the imperative need for additional crossings of the Fraser.

A subsequent study, prepared jointly by Foundation of Canada Engineering Corporation Limited and Christiani & Nielsen, recommended the construction of a four-lane tunsel at Deas Island. This was based on studies of possible locations at Port Mann, Annacis Island, Tilbury Island, and Deas Island, and on an analysis of traffic growth and future routes.

Physical Site Conditions

The area in which the tunnel is located is extremely flat, low lying, and bare of timber. It is protected from flooding by 6-foot dykes running downstream from Annacis Island to the mouth of the river.

Borings taken during preliminary studies indicated the presence in this area of a heterogeneous soil consisting of sand, silt and clay, with little uniformity of structure either in occurrence or in degree of compactness of the strata. The conditions suggested the possibility of considerable settlements for which allowance would have to be made in the design. However, a tunnel, unlike a bridge, would not impose any significant loads on the soil, and, therefore, would be a more suitable type of structure at this site.

The flow of the Fraser River, varying from 21,000 cfs. to 536,000 cfs. as measured some 60 miles upstream of the tunnel site at Hope, B.C., is markedly effected by tidal fluctuations in the Strait of Georgia. The tides and river discharge combine to give a water level range of 11 feet at the tunnel and a reversal of flow ranging from 7 fps. downstream to 3 fps. upstream.

The current in the river and the great variation in discharge combined with the nature of the bed material accentuate the scour and fill action normally observed in restricted channels at time of high water. In addition, material is transported in suspension while a bed load is carried along in the form of dunes.

A major consideration in the selection of the type and construction of a crossing at this site was that of providing adequate clearance for the navigation of ocean shipping moving up the Fraser to New Westminster. It was necessary to plan the crossing to provide not only the size of channel required at present, but also that which might be necessary at some time in the future. Since the channel in the Fraser must be maintained by extensive dredging it was also necessary to design the structure so as to avoid harmful changes in the existing scour and fill pattern.

Comparative studies of a bridge and a tunnel indicated that the tunnel could be built so as to avoid serious change in the hydraulic section of the river or dangerous reaction of the foundation soil.

In addition, the tunnel could be built more economically than a bridge and, in requiring vehicles to deviate only 80 feet from the horizontal as compared to 160 feet for the bridge, would provide for more economical passage of traffic.

As a result of the studies of traffic needs, site conditions, and the relative merits of a bridge and a tunnel, it was recommended that a tunnel be constructed under the Fraser River at Deas Island (see Fig. 8).

GENERAL LAYOUT and STRUCTURAL DESIGN

by T. Brœndum-Nielsen, P.Eng. and H. R. Kivisild, D.Eng.

THE APPROACHES at both ends of the tunnel are constructed as open troughs right out to the river banks to reduce as much as possible the length of the tunnel proper. Between each approach and the tunnel is a ventilation building. This general arrangement was found to provide an economical balance between the costs of the structure and those of the technical installations. The reduced length of closed tunnel made possible by this layout also affords a reduction in operating costs, as neither ventilation nor daytime illumination of the open approaches is required. All horizontal curves have been avoided to make passage of vehicles and inspection of traffic conditions easier.

Figure 2 shows a cross-section of the tunnel. There are four traffic lanes, each 12 feet wide, with a vertical clearance of 14 feet. The two-lane roadway for northbound traffic is separated from the southbound roadway by a longitudinal partition wall, the sides of which are sloped to improve acoustics. A bituminous road-surfacing has been chosen because of its smoothness, ease of repair, and sound-damping qualities. The two ventilation ducts, which run the entire length of the tunnel, are placed on the outer sides of the roadway tubes.

The subaqueous part of the tunnel consists of six precast reinforced concrete elements, each about 344 feet long, 78 feet wide, 24 feet high and weighing approximately 18,000 tons. The elements are cast in a dry dock excavated for the purpose near the site and later floated out and sunk in position in a trench dredged in the river bottom.

The tunnel elements are waterproofed with a 3/16 inch steel plate under the bottom slab and a bituminous membrane of the built-up type on the walls and the roof, except for a distance of 11 feet at each end of the tunnel elements, where a collar of 3/16 inch steel plate is used to facilitate the complete waterproofing of the tunnel at the joint between the elements. Steel plate waterproofing is also provided within areas of the roof where embedded parts penetrate the membrane.

The waterproofing membrane (asphalt with glass fibre reinforcing) is protected by a 4 inch thick layer of reinforced concrete under the bottom and on the top, and by 4 inch wood planking on the walls.

When an element has been sunk into its final position in the trench and temporarily joined to the element previously sunk, sand is jetted between the element and the bottom of the trench, and backfilled at both sides of the tunnel element. The river bottom is protected by means of articulated reinforced concrete mattresses covered by a layer of stone and rock, and rock protection is placed on top of the tunnel.

Approaches

Traffic requirements have determined the roadway geometry and thus the basic dimensions for the 1,800 ft. long approach on the Lulu Island side, which is shown on Fig. 3. The roadway drops 50 ft. over the length of this approach.

Both approaches and access roads are on extremely flat land, little developed and almost bare of timber.

Fig. 1. Map of Vancouver area.

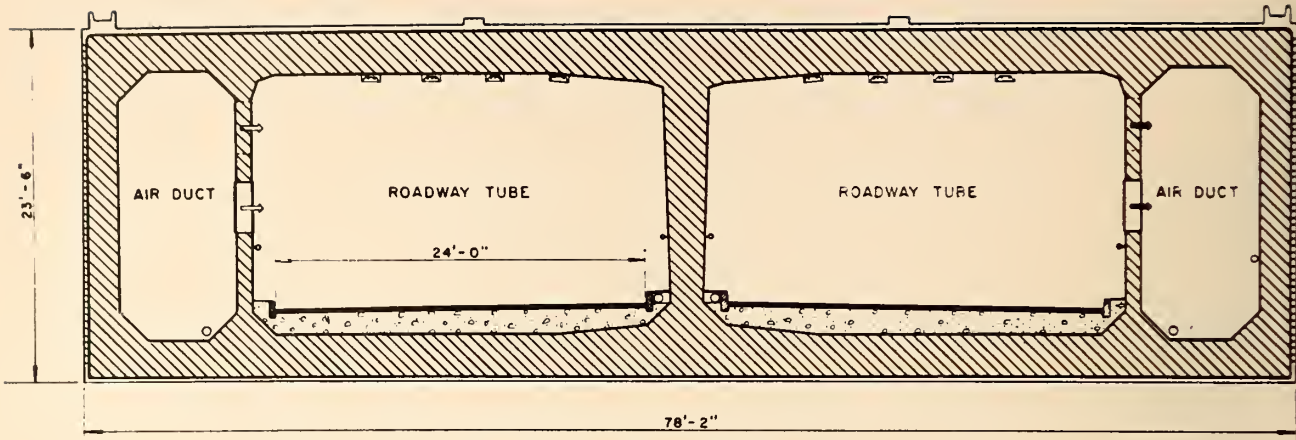


Fig. 2. Cross section of tunnel.

These factors favoured the adoption of the deep open approaches, which were designed as concrete troughs (Fig. 3 and 4).

A central wall running between the roadways for a distance of 420 ft. from the portals assists in ventilating the tunnel. This wall prevents the passage of vitiated air from one tube of the tunnel to the entrance of the other where it might be sucked into the tunnel.

Aluminum louvres are placed above the roadway for 310 feet in front of each of the two tunnel entrances and for 186 feet at the exits. By shading the roadway from direct sunlight, these louvres provide a transition, on sunny days, from bright sunlight to the lower light intensity in the tunnel.

Between each approach and the tunnel proper, a ventilation building provides a transition between the open trough and the closed subaqueous portions (Fig. 3 and 5).

Approach areas on both sides are a few feet above average river stage, but below high water stages. Although the north approach is behind the river dyke system, additional earth dykes encircle the approach area on both sides.

These dykes protect the approaches against crests of waves and surges and daily flood peaks. Under normal conditions the water is retained by the concrete walls of the troughs. If these walls had been built to retain maximum river stages, sections would have had to be increased considerably, with higher overall cost.

The mild climate with shallow maximum frost penetration depth (2.5 feet in normal soils) permitted the foundation of roadway troughs directly on the soil with bottom slab thickness varying for structural reasons only.

The troughs were designed as reinforced concrete sections. Two sections of approach structure were evolved, one being the gravity type trough used in the shallower parts and the other being one with cantilevered slabs extending into the earth to provide safety against uplift. (Fig. 5.) At the deepest portion the side walls are strutted.

Because of the heterogeneous nature of the subsoil, with lenses of sand, silt and clay, it was found advisable to divide the approach structure into 30 foot and 46.5 foot units connected by keys. The whole of the outer surface of the structure is waterproofed with an asphalt and fibreglass membrane, and the joints are provided with polyvinyl waterstops.

Basic dimensions of the concrete troughs give sufficient safety against uplift and excessive deflections. Since the trough dimensions are very sensitive to changes in stability requirements and soil properties, a whole range of conditions was investigated, and sliding was studied along various possible planes. Since the tunnel is located in a zone 3 earthquake area, various combinations of horizontal and vertical accelerations were considered. Because of the possibility of sand quickening under shock, a lowering of soil friction angle by vibration was taken into account. The combinations used were 0.21g with a friction angle of 30°, 0.1g with a friction angle of 20°, and gravity acceleration only with a friction angle of 15°.

As the main load in the structural design of side walls, a pressure of soil at rest combined with water to the crest of the troughs was considered. Reversal of stresses was checked by assuming only active soil pressure and a lowered ground water level. The calculated reinforcing was checked for forces acting during earthquakes.

In the main troughs, shear reinforcing was eliminated by increasing the thickness of the slabs. Longitudinal reinforcing was provided in gravity sections on the basis of subgrade drag theory and in the heavily reinforced units on the basis of the minimum required to distribute cracks as specified by building codes.

Ventilation Buildings

The ventilation buildings house the main fans for the tunnel and the necessary equipment for the control of the ventilation, lighting and traffic.

As already mentioned, it was considered necessary to divide the approach into relatively short units. For the same reason the ventilation buildings were made self-supporting so that they act as dams founded on slabs.

The walls on the river sides of the ventilation buildings retain earth and water. These forces are carried down to the base slabs by three longitudinal internal partition walls and by buttresses on the river side. These frames act in the same way as the buttresses of a buttress dam, although in this case they are working basically in tension.

Tunnel Section

The structural design of the tunnel section was made in accordance with the National Building Code of Canada.

The loads on the tunnel are: (a) weight of tunnel; (b) water pressure corresponding to high water level; (c) rock fill and sand deposits on the tunnel; (d) soil reaction; (e) frictional forces, i.e. vertical forces on the outer walls of the tunnel, caused by differential settlements of the ground below and outside the tunnel; (f) earthquake loads.

For ordinary loads, items (a) to (e), the allowable stresses were computed in accordance with the National Building Code of Canada.

The Hardy Cross moment distribution method was adopted in the analysis of the cross-sections of the precast tunnel elements. A number of cross-sections were analysed, a considerable number of load combinations being considered for each. In order to reduce the amount of calculation required, certain unit loading cases were chosen, for which the bending moments and normal forces were calculated. Any load combination could then be calculated easily by appropriately superposing the effects of the unit loading cases chosen.

The analysis proved that a uniform cross-section was appropriate for the entire length of the tunnel, and that even the reinforcement could be the same for all cross-sections, except for a few minor variations near the ends of the tunnel.

In the floating tunnel element, bending moments occur in the longitudinal direction. These were kept within permissible limits by an appropriate placing of the ballast and did not, therefore, necessitate additional reinforcement.

Differential Settlements

According to the subsoil investigations, the layers directly below the future tunnel bottom are mainly compressible silt. The influence of the settlements of these layers was investigated. Undisturbed samples were taken from the silt layers by means of thin-walled tube samplers and Oedometer tests were carried out on the samples extracted.

As the weight of the tunnel and backfill will be less than the weight of the soil dredged from the trench, the movement of the bottom of the trench will correspond to rebound when the trench is dredged, followed by some compression after the tunnel is placed. From the settlement calculations, it was found that the probable settlements would be 3 to 4 inches.

The tunnel was analysed as a beam on elastic foundation, loaded with a sinusoidal load having a maximum corresponding to rock fill plus 20 feet of sand, and a minimum corresponding to rock fill alone.

The tunnel structure was designed to be capable of following possible differential settlements without cracking. This called for a shallow cross-section, which was obtained by placing the ventilation ducts within the height occupied by the roadway tubes.

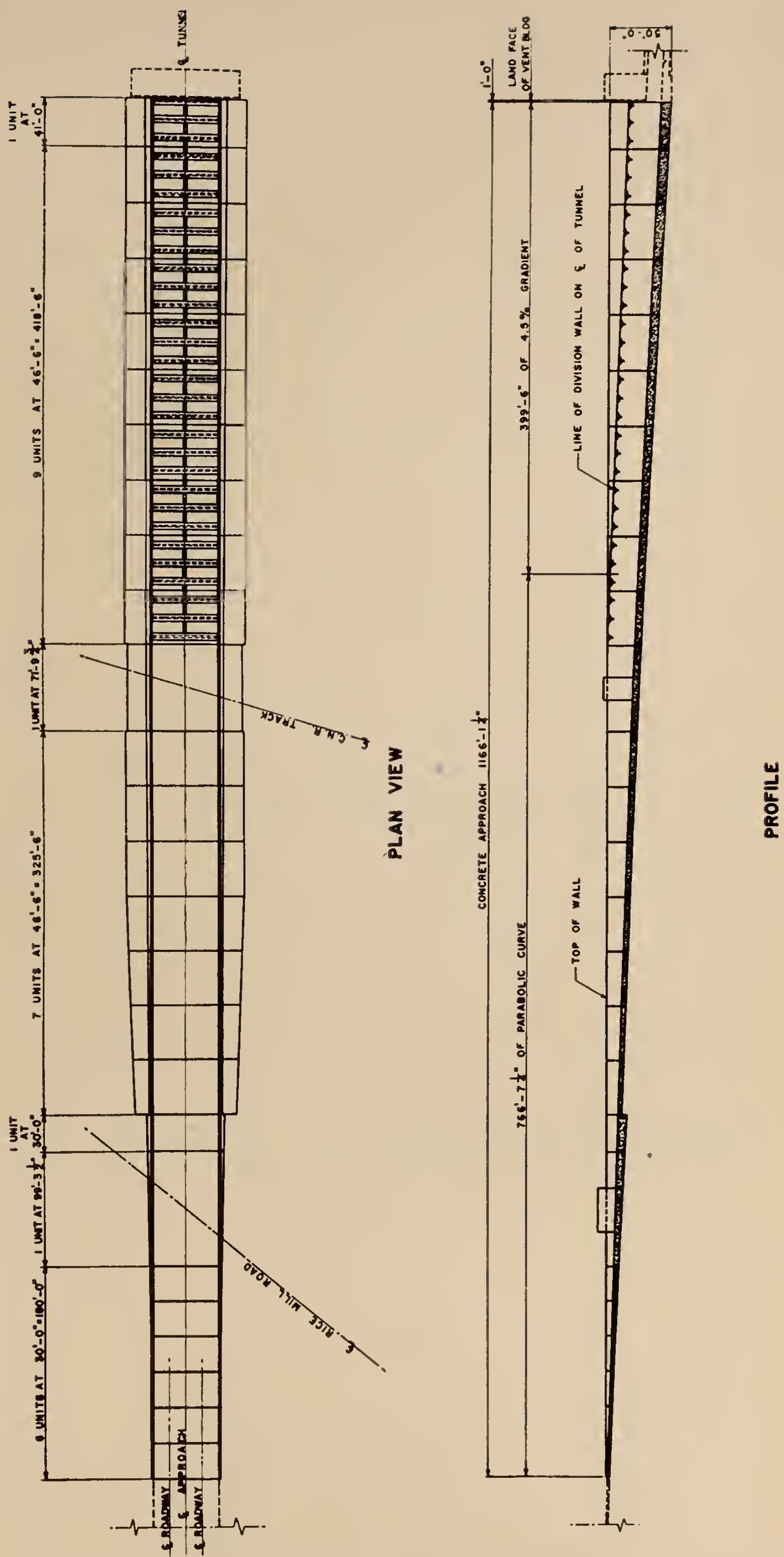


Fig. 3. Layout of Lulu Island approach.

The backfill on both sides of the tunnel represents a heavier loading on the silt than does the tunnel proper. This includes differential settlements which result in vertical friction forces between the backfill and the outer walls, with corresponding vertical shear stresses also transferred through the soil above the tunnel in the planes of the exterior lateral faces of the tunnel. These loads were taken into account in the stress analysis and were calculated by equalizing the elastic deformations of the cross-section and the corresponding settlements of the silt. Different distributions of the soil reaction beneath the tunnel were considered, and for each case the vertical friction forces and shear stresses were calculated. It was found, however, that the deformations of the cross-section and consequently also the stresses in the tunnel were practically independent of the assumed distribution of soil reaction.

Earthquake Resistant Design

The literature on earthquake resistant design of buildings is mainly confined to structures above ground level. Very little information is available on structures below ground level, and it is generally assumed that these suffer less damage during earthquakes than do structures above ground.

Since the Deas Island Tunnel is located in a zone 3 area, the effect of earthquakes on tunnels was studied thoroughly.

The conventional design procedure for structures exposed to earthquakes is to apply a horizontal acceleration to all parts of the structure. The acceleration of the masses of the different parts of the structure gives corresponding horizontal forces. The acceleration applied is often taken as 10 per cent of the acceleration of gravity but different values may be specified. The National Building Code of Canada specifies different values depending on the site and the type of structure.

By applying a horizontal acceleration to the earth mass, shear stresses will be set up in the soil. This method of approach corresponds, therefore, to shear waves transmitted through the medium. It is obvious that the shear stresses caused by the horizontal acceleration cannot exceed the shear strength of the soil, for if they did a failure would take place and the total energy of the earthquake would not be transmitted.

The maximum possible acceleration of shear waves will depend upon the shear strength of the medium through which the waves are transmitted. The maximum intensity observed on light geological formations is about 8 in the Modified Mercalli Scale, corresponding to an acceleration of 27 per cent of the acceleration of gravity.

During earthquakes, the stress changes take place so rapidly that no water can escape from the pores of the soil, which consists in this case of rather fine sand. The stress changes will result, therefore, in excessive pore pressures.

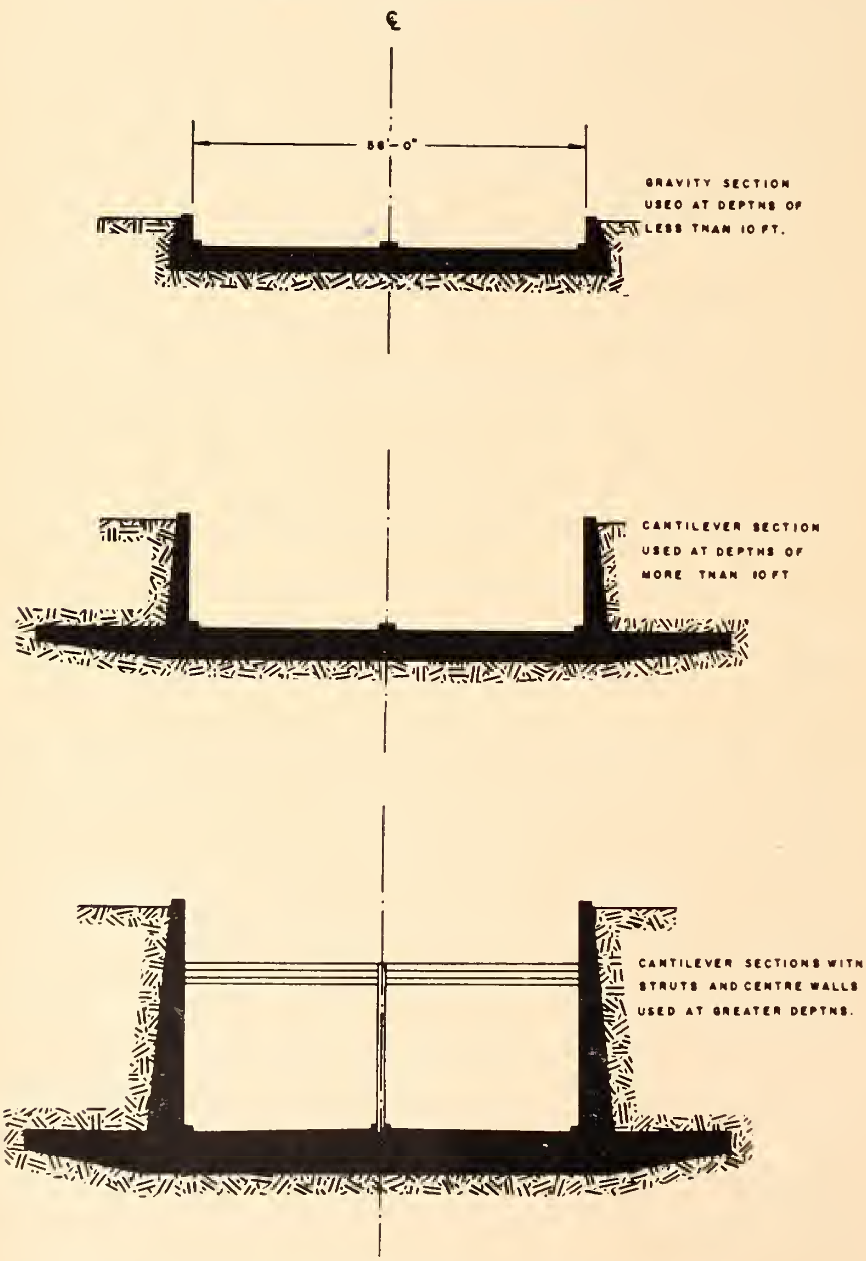
From theoretical considerations it was found that shear waves with an acceleration exceeding 21 per cent of gravity would cause failure in the soil. Thus the soil would not be capable of transmitting stronger shear waves.

The design was based, therefore, on a maximum acceleration of 21 per cent of gravity. For this acceleration, shear forces equal to 21 per cent of the overburden were assumed to be transmitted to the roof of the tunnel. In addition, an increase in the soil pressure on the outer walls of the tunnel, up to a value corresponding to the pressure from a liquid of the same density as that of the sand, was assumed.

The tunnel was so designed for this loading condition, corresponding to the failure condition in the soil layers, that the stresses exceed neither the yield point of the steel nor the compressive strength of the concrete.

Before it was finally decided to

Fig. 4. Types of approach units.



base the design on the above principles, an attempt was made to approach the problem in one of the following two ways:

A theoretical study of harmonic compression waves through an elastic medium showed that the effect of such waves corresponds to an increase in the soil pressure on the outer walls of the tunnel, which was in accord with the corresponding increase arrived at by the above considerations based on shear waves. Compression waves, however, do not cause shear forces on the tunnel (sidesway) and are consequently less dangerous than shear waves.

The results of a large number of earthquake tests on retaining walls backfilled with sand were studied. According to these experimental data, the increase in soil pressure on the outer walls of the tunnel would be smaller than the increase found by the theoretical shear wave considerations.

As a result it was found that the shear wave theory led to the most conservative design. Moreover, the structural analysis proved that a design based on this theory would require only slightly greater quantities of materials than would be the case were earthquake loading completely neglected. Consequently, it was decided to base the design on the shear wave theory.

Safety Against Uplift

For the completed tunnel, the factor of safety against uplift, under the most unfavourable conditions, is 1.16. All loads were checked during the construction period in order to reveal possible deviations from the design assumptions. If the frictional forces between the backfill and the outer walls were taken into account, the factor of safety against uplift would be 1.28.

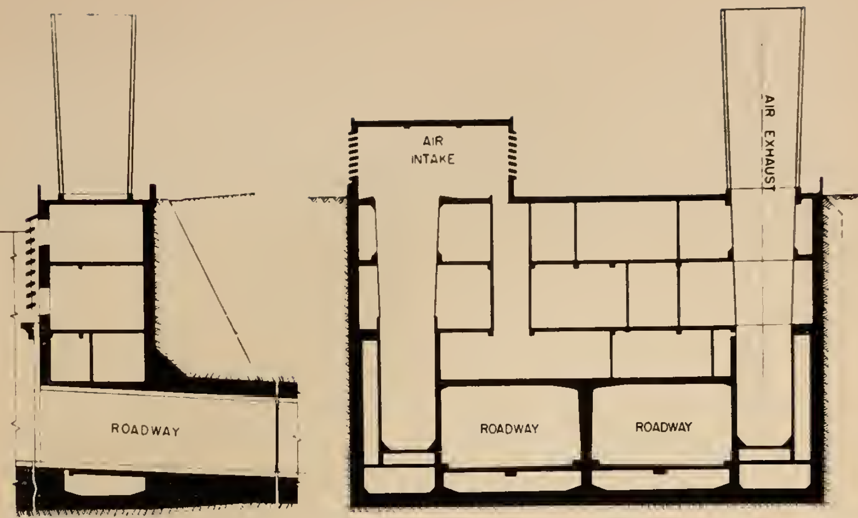


Fig. 5. Layout of ventilation buildings.

HYDRAULIC DESIGN

by H. R. Kivisild, D.Eng.

THE CROSSING is about 6 miles from the mouth of the Fraser River, and well within the tidal range which extends some 50 miles farther upstream. Normal tidal range is about 6 to 8 feet outside flood periods. Tidal currents are strong, reversing the flow during low discharge periods.

The river discharge is low during the winter, averaging approximately 21,000 cfs at Hope, B.C., with a minimum of 12,000 cfs. During the spring freshet, a discharge of 536,000 cfs has been recorded at Hope. A peak of 700,000 cfs is estimated to have a frequency of once in 1,000 years. At the site, outflow from various lakes between Hope and the site increases the discharge. This increase is again reduced by diversions to the North and Middle Arms a few miles upstream from the site.

During flood periods, river currents at the site are governed by discharge; during the winter months tides are the major cause of currents. Definite current patterns were established by velocity measurements and related to predict favourable periods for sinking operations.

The mildness of the climate precludes appreciable ice formation on the lower reaches of the Fraser River, except during the infrequent periods of low temperature. Local ice is not important, but ice floes from upstream may be up to 100 feet in diameter and a few feet thick.

Since the river current reverses during winter months, some salt water is carried upstream past the site. The salt water, being denser than fresh, takes the general form of a wedge, lifting the fresh water as it progresses upstream. The density of water on some days has varied from 1.00 at the surface to 1.02 at the bed. Obviously, this wedge had a special importance in planning sinking operations.

River Regime

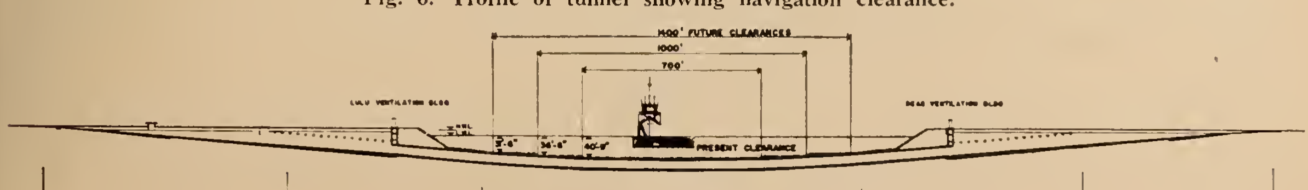
The current in the river, combined with the nature of the bed material, gives rise to considerable scour and fill action. A portion of the material is transported in suspension while the bed load forms dunes along the channel. These dunes have reached an amplitude of 15 feet with a length of 500 feet and may move downstream at a rate of up to 250 feet a day.

The river is constrained by dykes and revetments. Thus the shores are fixed. The only meandering is the shifting of the talweg and river bed contours from year to year.

Existing data on the river regime were supplemented by periodic soundings, bed load measurements, and trial trenches in the river bed. On the average the bed load samples were made up of 10% coarse sand, 80% medium sand, and 10% fine sand. Bed load was found to follow Schoklitsch's law for sedimentation.

For a study of tunnel effects on

Fig. 6. Profile of tunnel showing navigation clearance.



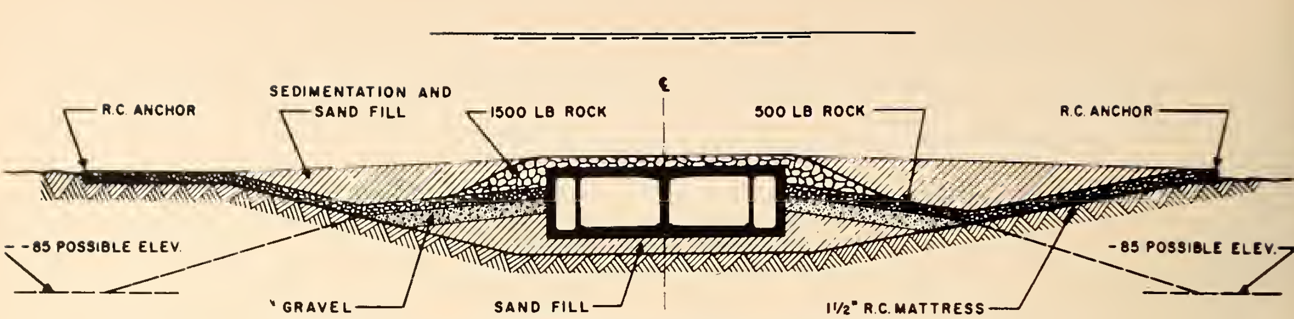


Fig. 7. Cross section of tunnel in place.

river regime, future river channels were estimated. These depend on various alternative river training programmes.

A certain amount of dredging is required to maintain definite depths and widths and also to provide a desirable course for any fairway. In addition to these corrective dredgings, continuous or periodic excavation of river bed material would be required if the section of the river with the planned fairways gets out of balance, and in the Fraser River the amount of dredging rapidly becomes very high.

Assuming the future characteristic discharge to be the same as at present, the maximum stable depth from low water will be about 28 feet for a 1400-foot fairway when the river is trained to that width and 37 feet for a 700-foot fairway inside the larger channel. Navigable depths are about 8 feet less than the average depths of stable fairways given above because of bed waves which reach 15 feet in the lower Fraser River.

Navigation

At present, the main river traffic of deep sea vessels past the site is directed to the Port of New Westminster, and amounts to some 400 vessels totalling about 2.5 million gross tons. Present navigation clearance is 22.5 feet below low water over a width of 300 feet.

For future navigation, the Department of Public Works has specified considerably larger clearances, which have been followed in the design (Fig. 6). The subaqueous tunnel is placed at a level to give the following clearances at minimum water surface elevation over the tunnel for a future channel: 31.5 feet over a width of 1,400 feet; 36.5 feet over a width of 1,000 feet and 40.75 feet over a width of 700 feet.

These estimated stable fairways fall within the clearances at the tunnel. The following clearances for navigation will be provided during various tide phases:

River Clearances

	Ord. Low Water	Ord. High Water
Tunnel Clearance		
1400 ft. width	33	39
700 ft. width	42	48
Stable Channel		
1400 ft. fairway	21	27
700 ft. fairway	30	36

The elevation of +3.5 feet GSC adopted for ordinary high water is reached practically daily for several hours and is thus a safe figure for navigation.

The Fraser River stable channels are comparable to those of the major navigable tidal rivers in the world, and the tunnel provides more than these clearances.

River Bed Protection

The tunnel and river bed upstream and downstream of the tunnel are protected by an apron. Its main purpose is to protect the tunnel itself against undermining, but it also provides a gradual guidance of river flow from the natural river section to the wider and shallower tunnel section and back to the river section, almost eliminating the effects of turbulence downstream.

Model tests showed that the depth of talweg is only mildly increased by the presence of the tunnel. On the basis of these tests, the only protection required was against the natural lowering of the river during flood periods. The blanket adopted (Fig. 7) was chosen because it could be placed in the river bed with a minimum of dredging and, as a flexible self-launching apron, would follow natural river bed contours.

On top of the tunnel and for 50 feet on either side, 1500 lb. stones are placed in double layers as protective armour over a double layer of 500 lb. rock and 5 feet of gravel. The heavy stones are required in this area because of the heavy turbulence encountered. From 50 to 100 feet from the tunnel the protection is made up of 500 lb. rock on a 1½ in. reinforced concrete mat. The mat extends for 15 feet under the gravel at the tunnel for anchorage and prevents the armour rock from sinking into the sand under the action of turbulence and pressure variations. At the extreme outside edges, the mat is attached to concrete anchor blocks, which also aided in the sinking and launching of the mats.

Bank Protection

Near the tunnel the shore protection below water level is basically the same as the river bed protection described above. Above water level for 600 feet, centred at the tunnel, rock armour on a gravel filter is used. Farther away from the tunnel, present guide banks are reinforced in some places by dumping rock.

Model of Sinking Operations

Hydraulic model tests were carried out at the Hydraulic Laboratory of the Technical University of Denmark in order to determine the drag effects on the tunnel element before, during, and after sinking.

Results confirmed previous calculations and supplied the important information that downward forces exist when the element is floating and upward forces when it is near the bottom.

Model Tests of the Layout

The final geometric layout of protective works was determined on the basis of model tests which were carried out in the Fraser River Model at the University of British Columbia under the direction of Professor E. S. Pretious. These tests gave flow and river bed conditions at the tunnel and showed the effects of the tunnel on the river regime.

The Fraser River Model has been discussed elsewhere. In general, it is a tidal, loose boundary model treating the lower Fraser River up to 56 miles from the mouth. Horizontal scale is 1:600 and vertical scale is 1:70.

The model bed for the Deas Island Tunnel erosion and sedimentation tests was moulded in the tunnel area to 1955 pre-freshet soundings and elsewhere to 1954 pre-freshet soundings. The hydraulic regime for verification and for normal maximum operating conditions was the 1950 natural tide period with freshet discharges. As an extreme case, a flood with a discharge of 700,000 cfs at Hope was also imposed. River beds with and without the tunnel were compared in both conditions mentioned.

The model test showed that the blanket design adopted, with armour at river bed level, gave the smallest scour effects for all alternatives. Tests indicated some local scour upstream of the tunnel to a maximum depth of 15 feet in extreme conditions. Downstream the influence of the tunnel was small, although it appeared to increase somewhat the tendency to shoal along the north bank.

At Kirkland Island Nose, the bed showed considerable scour, both with and without the tunnel when the 1000 year flood conditions were imposed.

After erosion tests, flow patterns were also studied. Flows before and after, both with and without tunnel, were practically identical, the only difference being a slight separation from the north shore downstream of the tunnel. Discharge distribution between the Main Arm and Ladner Reach was substantially unchanged. The tests showed no measurable drop of water surface elevation under any conditions.

Model Tests of the Blanket

Preliminary tests were run at the University of Alberta by Professor T. Blench, while the final series of hydraulic model tests to investigate the structure of the protective blanket was conducted under the direction of Professor E. S. Pretious in a glass-filled flume in the Hydraulics Laboratory of the University of British Columbia.

These flume tests could not be used to determine flow patterns or the effect of the tunnel on river levels. In the flume, the flow in the deepest channel, which was the section modelled, could not be redistributed sideways when restricted by the tunnel. In practice, the mild slopes of the blanket will redistribute the flow with only minor turbulence losses. Therefore, the more general phenomena were tested in the Fraser River Model, as already described.

As a first result, a run at 600,000 cfs showed that the protection with 500 lb. prototype weight was inadequate on top of the tunnel, and new protection with a prototype weight of 1500 lb. was substituted. It also became evident that downstream blankets could be shortened.

The blanket, as constructed, seemed stable under the 1000 year flood of 700,000 cfs at Hope with water surface at extreme low of 9 feet GSC at the site. Near the tunnel, 1500 lb. rocks were stable as were 500 lb. rocks at a greater distance from the tunnel.

At some stages in the tests, sediment collected on the apron but the shoals never rose above the crest of the tunnel. Furthermore, the flow in the tunnel area showed no harmful eddies in any of the tests.

Field Observations

Soundings at the site showed that the apron as built followed the design quite closely and, therefore, the effect on hydraulic conditions in the river regime could be expected to be the same as shown by model tests. This was verified by a series of field measurements.

During the construction of the protective apron, soundings were run at short intervals, as many as two a week towards the end of the construction period. The soundings showed considerable variation from natural conditions immediately after completion. The changes became less pronounced gradually and after the freshet the river bed was essentially the same as in the year before the placing of tunnel elements. The only change was the actual area of the tunnel mound.

Velocity measurements were carried out along the tunnel centreline which showed that the protection guides the flow as designed. Velocities did not increase except at the north bank and, after completion of the blanket, turbulence became negligible.

Flow distribution studies between the Main Arm and Ladner Reach showed no deviation from previous years.

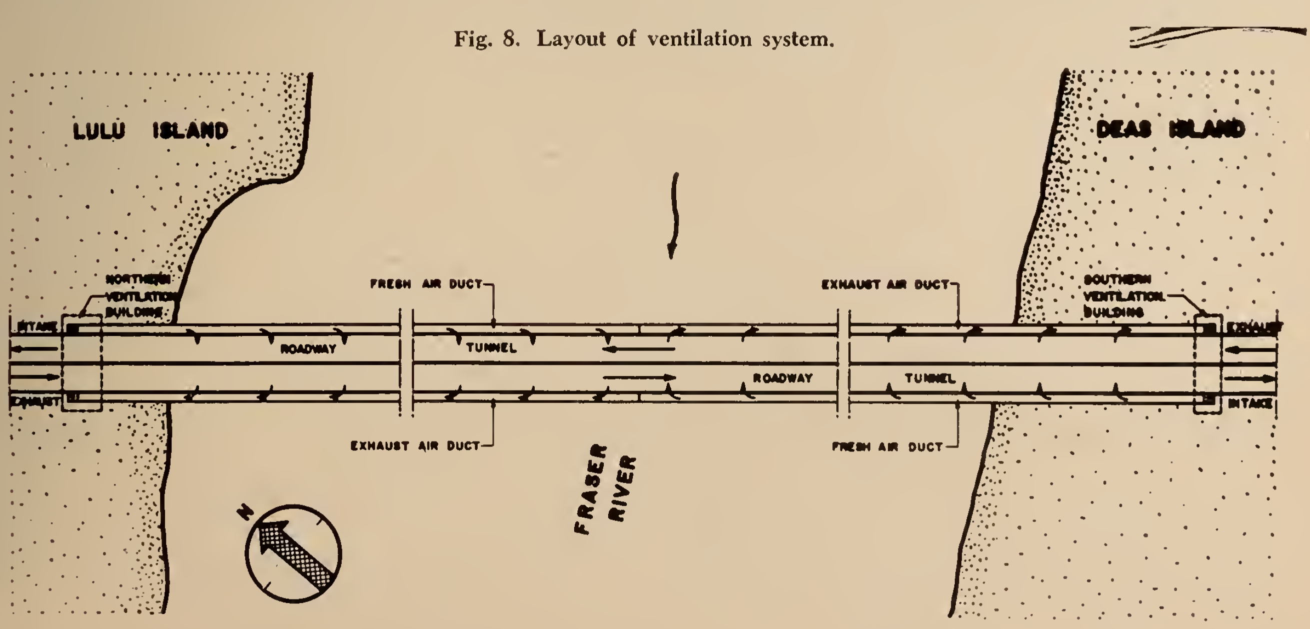
As was expected from the model tests, the tunnel was covered with silt on the southern half. On the northern half only the top of the tunnel is bare. No instability was observed anywhere on the blanket.

Relation of Studies to Design

As shown above, the variations in discharge, tides and water density affect the sinking procedures. However, a reliable method of forecasting the effects was devised by a combination of site investigations and theoretical studies.

Field measurements after construction showed that thorough hydraulic model studies make a reliable design of protective blankets possible.

Fig. 8. Layout of ventilation system.



TECHNICAL INSTALLATIONS

by A. T. Jeffrey, P.Eng.

THE BASIC DESIGN requirement is the provision under all anticipated conditions, of safe, rapid passage of vehicular traffic from portal to portal. This necessitates sufficient ventilation and lighting with adequate detecting and operating controls to govern traffic movement and ventilation and lighting programs under all possible conditions of carbon monoxide occurrence, fire, poor visibility, accident, wind and light. Such control necessitates the provision of the most reliable sources of power available, with alternative emergency sources.

Ventilation

Basic tunnel ventilation is provided by four reversible fans, capable of handling up to 1,000,000 cubic feet of air a minute, which create the main circulation of air in the semi-transversal ventilating system indicated in Fig. 5. The fans are located in the two ventilation buildings. (Fig. 5) Operation is controlled from a room in the northern building either by the automatic control system or manually by a tunnel operator.

During normal traffic conditions the air movement in the tunnel is the sum of the air movement caused by the mechanical ventilation and the air flow induced by the traffic.

For the mechanical ventilation fresh air is drawn into the tunnel through the entrance portal and exhausted laterally into the air passage over the first half of the tunnel. In the second half air is introduced into the tube and leaves the tunnel at the exit portal. The traffic air-flow velocity depends on the intensity and speed of the traffic.

As all four fans are reversible, the suction-pressure ventilation will be combined in case of fire so that smoke and heat will be removed from that part of the tunnel where cars are held up by the fire.

No spare fans are installed in the tunnel. When one fan is out of operation, for maintenance or any other reasons, a damper, located in the ventilation duct at the tunnel mid-point, can be opened and the other fan serving this duct can be used for ventilation of the full length of the tube.

The normal operation of the ventilation system is programmed by a master clock system adjusted for a 7-day period and over-ridden by carbon monoxide analysis and visibility indicators. The ventilation system may also be controlled manually by the operator. Fire ventilation is controlled automatically by the fire detectors.

Power

Under normal conditions, power is supplied by the British Columbia Electric Company at 12,500 volts from the north side of the river. This is stepped-down to 480 volts, which is the operating voltage for the tunnel motors and lighting, at a 450 kva-substation at each ventilation building.

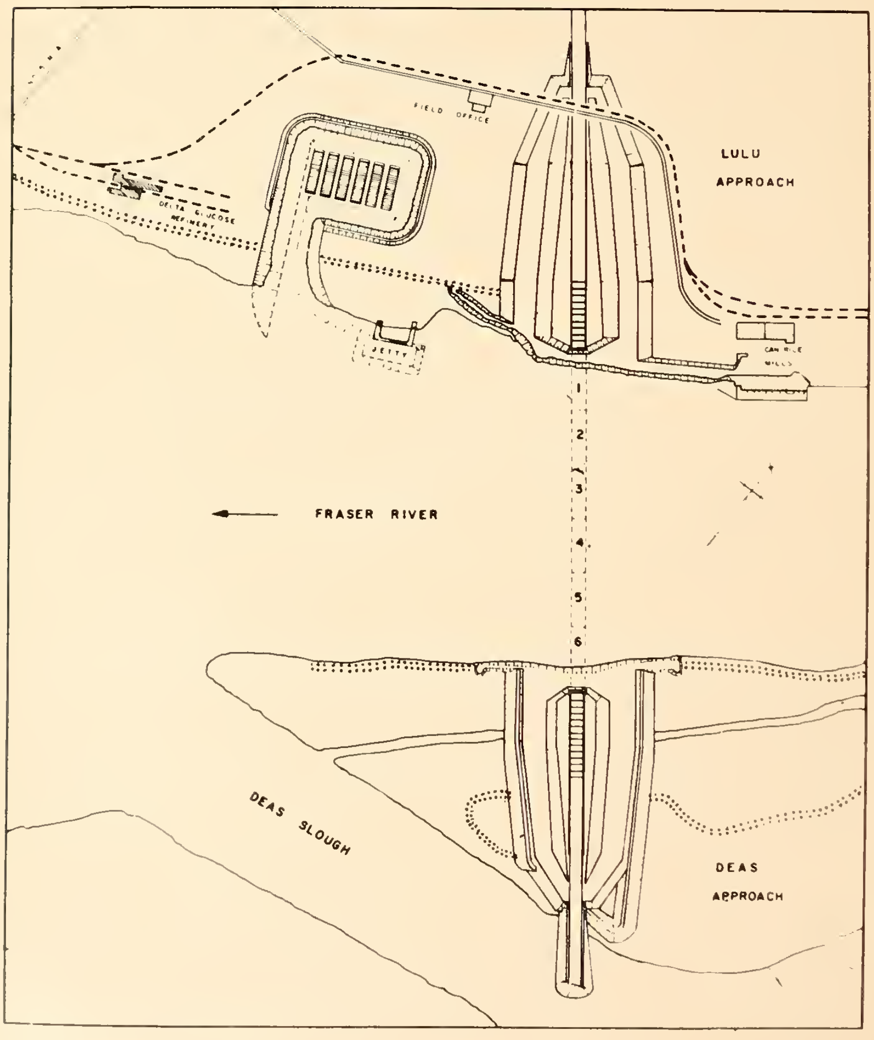
Should the normal power feeder fail, an automatic transfer is effected by means of interconnected oil circuit breakers at opposite ends of the tunnel to an alternate source of power at the south end. Should this second source also fail, the 150 kw. diesel generator is automatically started and put on the line. This will supply the ventilation motors at reduced speed, approximately half of the total tunnel light, all electric control circuits, and all the essential pumps.

During the 10 to 15 seconds it takes for the diesel generator to start, power is supplied to provide 12 kw. at 440 volts, 60 cycles, for minimum lighting requirements by means of a special motor generator set. The set consists of an A.C. generator, A.C. motor and D.C. motor, all on a common shaft. Normally the A.C. motor drives the A.C. generator. If power fails, the D.C. motor, supplied from a set of nickel-cadmium batteries, takes over well within 8 to 10 cycles thus ensuring no appreciable interruption of lighting.

Due to the long runs through areas of varying temperature, it was felt that condensation would occur within conduit runs. For this reason, it was decided that all power runs of 480 volts and lower would be made in TECK cable with a vinyl jacket over the armour to provide a maximum of protection against deterioration both of armour and of the rubber insulation.

The lateral runs to equipment located in the roof of the traffic section of the tunnel, which are fairly short,

Fig. 9. Layout of construction site.



are rigid conduit embedded in the concrete using RHRW insulated wire.

Control runs are made in multi-conductor type T insulated wire with a vinyl jacket over the bundled conductors.

Telephone wiring in the tunnel is by means of ALPETH type telephone wire with polyethylene insulation of the armour.

Lighting

Lighting of the tunnel is normally controlled by the programming clock. In case of extraordinary outdoor light intensity, this control will be overridden by photo-cells mounted at the tunnel entrance portal. The lighting will thus always correspond to the illumination on the approaches.

As this is an unlined tunnel with a normal concrete surface finish, reflector type waterproof fixtures have been used rather than some of the so-called tunnel types, which are designed primarily for tile-lined tunnels. Main tunnel lighting is provided by 430 and 800 milliamp 2-lamp fixtures.

Louvres over the tunnel approach for approximately 310 feet in front of the two entrances and 186 feet at the exits, provides proper transition between the levels of daylight and interior lighting. Immediately inside the tunnel entrance portal, the lighting level is of the order of 85 foot-candles, tapering off to approximately 10 foot-candles about 700 feet from the portal and 5 foot-candles in the remainder of the tunnel. This is designed to enable the eye of the average driver to adjust from the bright sunlight condition normally occurring on the highway to the relatively low level which is feasible in the tunnel. These levels and areas of lighting provide adequately for eye adaptation of a driver travelling at 60 miles an hour.

Power for lighting is provided at 440 volts primary, and the varying levels of illumination are obtained by automatically switching groups of lights.

Consideration was given to high voltage series circuits and alternatively to 400-cycle high-frequency lighting. In view of the somewhat limited length of this tunnel, it did not appear desirable to use either of these alternatives. The basic system is designed so that appreciably higher levels of illumination can be obtained in the future with the same fixtures, by modification of lamps and transformers, and by conversion to a 400-cycle power supply.

Safety and Protective Measures

Safety and protective measures for the operation of this tunnel were taken care of in a number of ways.

Carbon monoxide content of the air is continuously monitored at six points in each tube. A carbon monoxide content of less than two parts in 10,000 parts of air is normal throughout the tunnel. Any reading exceeding this will start up the fans if they are not operating, or increase them to full speed if they are not already in this position. The presence of smoke, visible exhaust fumes or fog, which is monitored continuously by visibility meters located at four points in each tube, will also result in an increase of ventilation intensity.

In case of fire in the tunnel, the control of the ventilation is taken over by the fire detectors.

The exhaust fumes from vehicles held up during periods of heavy traffic flow can cause an appreciable rise in the carbon monoxide content of the tunnel air and a decrease in visibility within a short time. However, use of "stop engine" signs avoids any appreciable increase in carbon monoxide content.

Traffic Lights and Control

Traffic flow in the tunnel is controlled from the control room by means of traffic lights spaced 150 feet apart, which normally show a green signal. At the entrances to the tunnel, key-operated buttons permit group operation of the lights by police or fire department. These switches may be over-ridden from the control room.

At the traffic signal positions there are also portable carbon dioxide fire extinguishers, telephones, and hose racks equipped with fog nozzles, for fire fighting purposes.

Suitable illuminated traffic direction signs, operated from the control room, are provided at the approaches to divert all traffic into one tube if the other tube is to be closed for repairs.

Photo-electric overheight indicators set at 13 ft. 8 in. above the road surface (maximum tunnel clearance) will be installed at the toll booths to sound an alarm if an "overheight" truck should pass.

A measure of traffic control is also provided by traffic recorders which are essentially magnetic pick-ups embedded in each lane at the tunnel portals. The recorder signals are fed to counters on the main control panel. The number of cars in the tunnel is approximately the difference in totals between the entrance and exit counters.

Fire Protection

Fire protection is provided throughout by means of a dry valve sprinkler system and electrical fire detection heads in the roof of the tunnel. The activation of any fire detection head will indicate, by means of an annunciator system in the control room, the presence of a fire within approximately 75 feet in any portion of the tunnel. In addition, the removal of

Fig. 10. Lulu Island approach during construction.

Fig. 11. Tunnel elements during construction.

one of the portable carbon dioxide fire extinguishers will indicate, by means of a pilot light, that an abnormal condition has occurred.

Telephones

Telephones connected to the control room are situated approximately every 150 feet, next to the fire alarms and fire extinguishers. These telephones are available for use by the general public or the tunnel operators. Pilot lights on the main control panel indicate which telephone is in use. A throw-over switch is incorporated in the main switchboard so that at night, when the tunnel operator is not normally present, all telephones can be connected to the nearest central fire or police station.

Loudspeakers

Traffic within the tunnel may also be controlled under emergency conditions by a loudspeaker system operated from the main control room. Speakers are located approximately every 50 feet throughout the tunnel so that communication with vehicle operators is possible throughout the tunnel.

Drainage

Drainage at the portals of the tunnel and at the mid-point is by suitable pumps which can be operated at full capacity by either the normal or the diesel emergency power supply.

The road gutters in the approaches and in the tunnel can be maintained ice-free by means of buried heating cables embedded in the upper asphalt coating and operated manually or by thermostatic control at the discretion of the tunnel operator.

Tunnel Maintenance

The electrical and mechanical equipment is located in the air ducts paralleling the roadways where possible. The equipment mounted in the traffic tubes is of watertight construction since the walls and ceiling will be washed down with water.

Two features of the control are especially interesting. Use has been made of various types of supervisory circuits to indicate malfunction or servicing requirements on automatic equipment. For example, on the visibility photocells high-sensitivity series relays are used to close an auxiliary contact and indicate lamp failure on the main panel board rather than having it show up as a false reading as smoke or fog condition.

Extensive use is made of graphic panels in the master control room, and all traffic lights and traffic control signs are indicated by suitably coloured pilot lights on the main control panel. On the traffic control system an innovation is the use of low-voltage remote-control wiring for all traffic signal control. Some 60 traffic signals require almost 120 miles of wire in their operation and, with this system, the majority of this wiring can now be handled by No. 16 low-voltage plastic-insulated bundled conductors.

CONSTRUCTION PROCEDURES

by O. H. Bentzen, P. Eng.

CONSTRUCTION of a tunnel like the Deas Island Tunnel is, in itself, an undertaking somewhat out of the ordinary. Although for the major part of the project conventional construction methods were used, there are several features which are unique and others which are of more than common interest.

Construction of the Drydock

The first major operation was the preparation of a drydock for the construction of the tunnel elements. Fig. 9 shows the layout of the construction site. After a thorough investigation, it was decided to build a dock large enough to permit construction of all six elements at the same time and to minimize its distance from the tunnel centreline, so as to keep small the distance over which the elements had to be transported. The floor of the drydock was 633 ft. x 384 ft., an area of about 243,000 sq. ft., while total excavation amounted to 450,000 cubic yards of material, making it one of the biggest ever constructed in Canada.

In constructing the drydock, the contractor chose to use an hydraulic cutter dredger instead of land equipment to remove the silt and sand. This turned out to be a very wise decision since the wet ground conditions encountered during the October, November, December, and January season would have made the use of scrapers and bulldozers impossible.

The general level of Lulu Island is around +3 ft. Geodetic Datum (GSC) while the high water of the Fraser River rises as far as 6 ft to 7 ft GSC. For this reason, before the dredger broke the existing river dyke to gain access to the drydock site, it was necessary to build temporary dykes around the area in order to prevent flooding of the island. These temporary dykes were built by means of drag-lines with as many as nine machines working at one time. They had a crown of about 10 ft. and a base of 50 ft. The material used was taken from the silt which overlies the area to a depth of about 5 or 6 ft.

Following the dredging and plugging of the passage to the river, the excavation was dewatered, the first part by open pumping. Two 12-inch pumps, each with a capacity of 4200 gpm, lowered the ground water to —7 ft. GSC. After that, a ring of wellpoints was installed at —5 ft. GSC. These wellpoints, spaced at 5 to 6 foot intervals, were 1½ inches in diameter and were connected to a 12-inch header. The pairs of 12-inch pumps hooked up to the system lowered the ground water to approximately —21 ft. GSC. The banks were then sloped to grade and the second ring of wellpoints installed. This ring consisted of 2-inch wellpoints also connected to a 12-inch header. The length of the risers on this ring was about 30 feet in order to take advantage of an impervious layer of soil lying about 35 feet down. The ground water was lowered to approximately —31 ft. or 32 ft. GSC, leaving 7 to 8 feet of dry sand above the water table. After the ground water level was stabilized, the daily pumping amounted to about 5,000 gpm.

Construction of Approaches

The second major construction undertaken was that for the two approaches and the ventilation buildings. The dewatering problem for these structures was a much greater one than for the drydock. At the drydock the ground water was lowered barely 30 feet, whereas in the approaches, the water table had to be lowered about 60 feet. In addition, the approach excavations were carried right out to the river bank whereas the drydock was some distance back from the river. The contractor for the drydock managed to keep the excavations dry by using only the lower ring of wellpoints and leaving only part of the upper one in on the river side as a precaution. However, the contractor for the approaches was faced with the necessity of putting in four rings of well-points of which he had to operate three at maximum.

The excavation of the Lulu Island approach (Fig. 10) was carried out by scrapers and bulldozers and the sand deposited on the future dykes on each side of the approach. For Deas Island, the top 20 feet of soil was removed by suction dredger, the dewatering equipment installed and the balance of the fill taken out by scrapers and bulldozers.

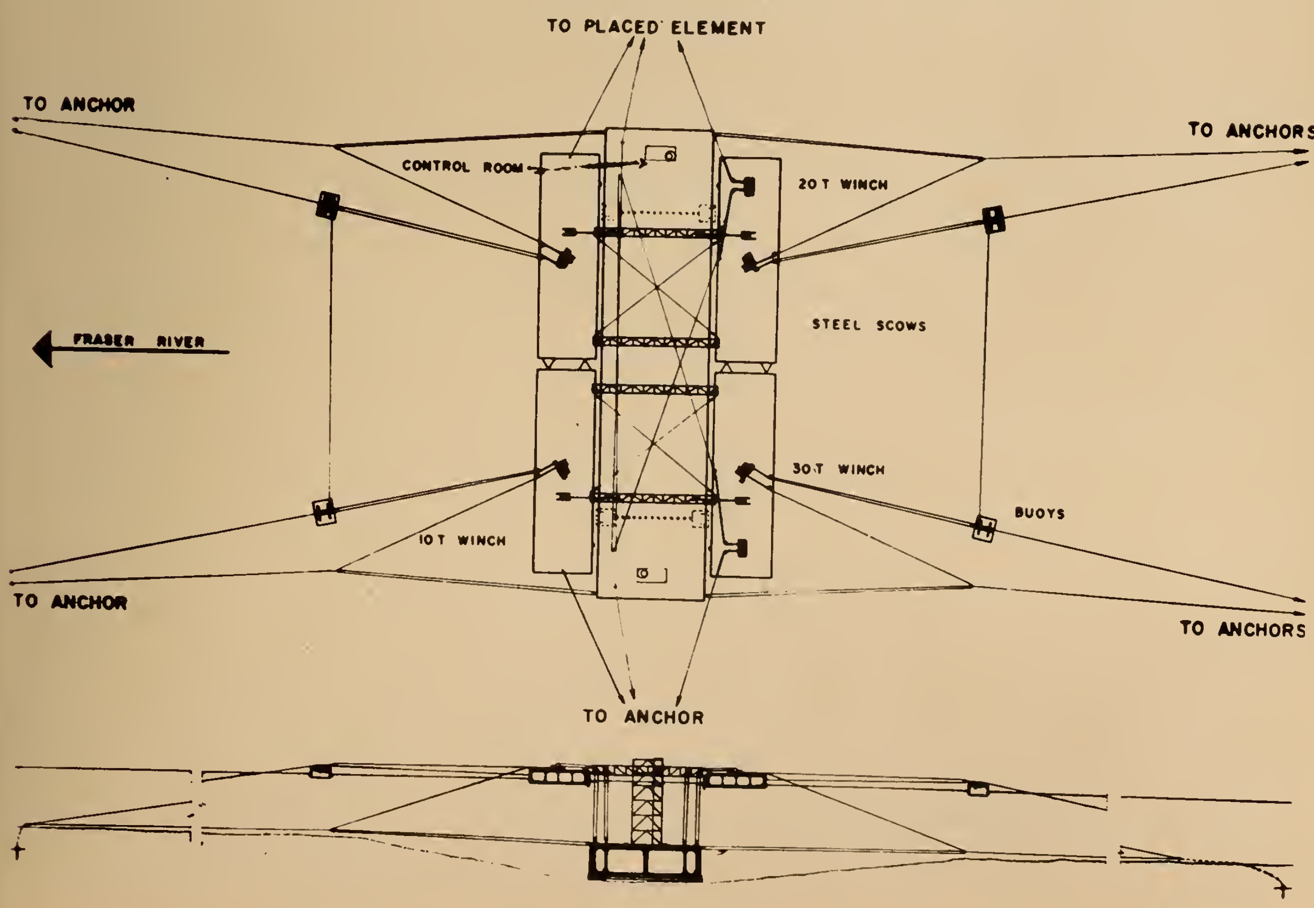
The dewatering of the Deas Island approach was carried out in a slightly different manner to that of the Lulu Island approach. Deep well pumps were installed on the Deas Island side in addition to the wellpoint system. The contractor decided to use deep wells because he had found indications from borings that a heavy layer of medium and coarse sand existed right down to approximately 100 feet below the surface. These deep wells were installed in the part of the excavation nearest the river and were served by five 14-inch and five 12-inch two-stage pumps.

As backfilling proceeded, after completion of the construction, the wellpoints from the dewatering system were withdrawn and the ground water was allowed to rise gradually. Water also was pumped into the approach structure in order to maintain the same level inside as outside so as to prevent lifting of the structure during this period. As soon as the water levels had risen to their maximum, the dykes facing the river were broken, at an appropriate stage of the tide, in order to provide room for the first tunnel element to be floated in and joined to the spout of the ventilation building seen in Fig. 5.

Construction of Tunnel Elements

The tunnel elements were constructed in the drydock by conventional methods, as has been mentioned in the section on the general layout and design of the tunnel. The ele-

Fig. 12. Floating rig.



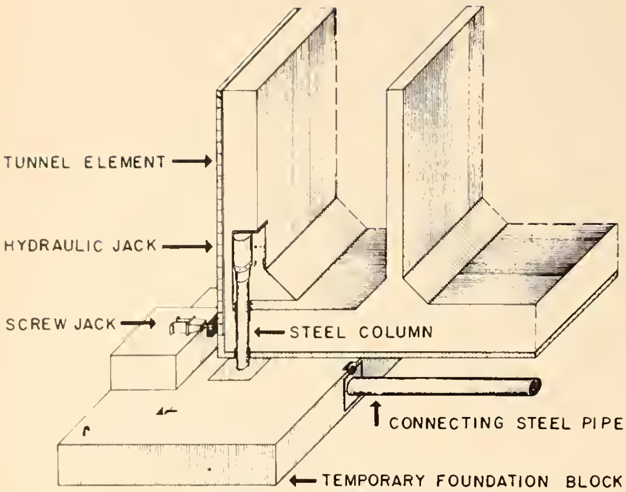


Fig. 13. Temporary foundation blocks.

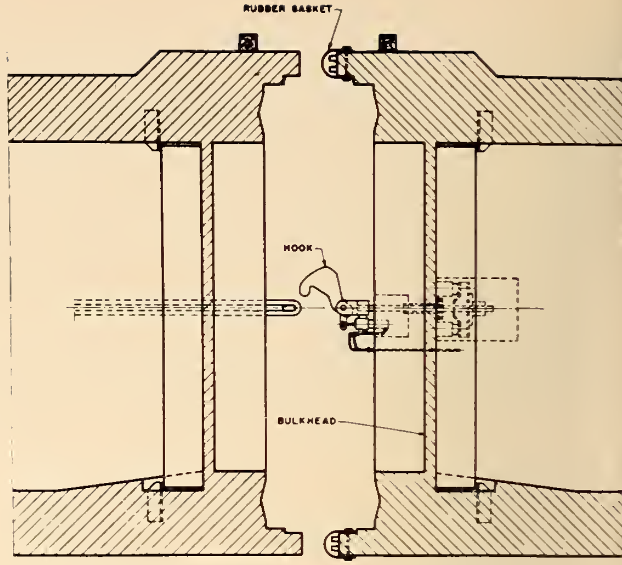


Fig. 14. Joint between tunnel elements.

ments are simply huge reinforced concrete boxes with temporary bulkheads at each end. Fig. 11 shows the elements under construction in the drydock.

Perhaps the most complex part of the element construction is the extensive waterproofing required, which has been described under "General Layout and Structural Design". The contractor had a certain amount of difficulty with curling of the steel plate forming the waterproofing of the bottom slab because of expansion and contraction caused by temperature variations. However, the contractor encountered no other difficulties in the fabrication of the elements.

After the elements had been completed, the drydock was flooded gradually by stages in order to test the watertightness of the concrete in the structures.

As construction of the elements and approaches neared completion, preparations were made for excavation of a trench in the river to receive the elements as they were placed. As has been indicated in the section on Hydraulic Design, it had been established by actual on-site tests, by hydraulic laboratory tests, and by theoretical studies, that a trench in the river bottom could be kept open long enough to permit the placing of the elements without too great a degree of silting. On the basis of the assumptions which had been made in the study of the excavation of a trench, it was decided to dredge only far enough in advance to permit of the placing of two elements without opening so much of the trench that redredging would be necessary. The assumptions were confirmed later by actual full scale tests at the site.

As the placing of the 18,500-ton tunnel elements had to be done to an accuracy of ⅛-inch, it was necessary to design very special floating equipment, special controls and special hydraulic equipment as well as to plan in detail the entire placing operation. An unusual feature is that there is access to the tunnel element before, during, and after the placing operation. In the normal procedure used for the placing of elements for a trench type tunnel this is not the case, and access is had only from the completed section of the structure when the temporary bulkheads are removed. In order to avoid delays in the execution of the complex placing operation and as time for the construction was running short, the special equipment and procedures to be used in the placing operation were designed by the engineer. Figure 12 shows a plan and a cross-section of the floating rig finally evolved for use in the placing operation and indicates to some degree the method of handling the element during the placing.

Primarily, the floating and sinking rig consists of four heavy steel scows, each 43 ft. x 150 ft., tied together by four steel trusses, the end ones supporting the heavy block and tackle used in lowering the elements and the central ones maintaining the proper distance between the scows. Winches are placed on top of the sinking rig scows, providing six drums for holding the entire rig in position, six winches for holding the element in the proper position, and four 10-ton electric winches used to control the lowering of the element through five-sheaved blocks.

The tunnel elements are lowered by admitting water to the ballast tanks within the ventilation ducts and then gradually slacking off on the supporting cables, permitting the element to sink gradually, always bearing the slope it will have in its final position. Within the elements themselves, two 8-inch electric pumps were installed and a complete piping system with valves was designed to enable the crew to fill or empty any ballast compartment to provide buoyancy as required during the operation.

The final accurate levelling of the element once it has reached the bottom of the river is accomplished by means of four 300-ton hydraulic jacks installed in the bottom of the tunnel element. The jacks, illustrated in Figure 13, are located approximately at the fifth points of the element, the two at one end of the element being connected so as give an effective three-point support to the element once it rests on the jacks. These jacks, which are controlled from inside the elements, operate 8-inch pistons which project through the bottom of the elements.

The temporary connection of the unit to the one preceding is accomplished by means of a hook and eye arrangement in the end of the tunnel unit, shown in Figure 14. The hook is capable of exerting a force of 150 tons by means of two hydraulic jacks inside the element. It is connected to the eye in the preceding element by hydraulic controls and, once in position, pulls the elements together in order to effect a temporary seal between the reinforced concrete collars, which form a temporary working chamber between the units within which workmen can complete the joint by connecting up the walls in both elements. One of the collars is equipped with an inflatable rubber gasket to ensure watertightness.

At the temporary jetty, for outfitting the elements prior to sinking, four concrete blocks, each 13 ft. square x 2½ feet deep, are suspended beneath it in line with the hydraulic jacks mentioned above. These blocks act as temporary foundations during the final levelling of the element and prior to the completion of the sand foundation which is jetted beneath the units. In addition, two access shafts and measuring towers, all electrical equipment, and special survey instruments were mounted on the roof of the element in preparation for the sinking operation as indicated in Fig. 15. Electrical power was provided by means of a diesel electric generator unit installed on one of the scows until such time as the element was in approximately its final position when a heavy armoured electrical cable was run from the shore to provide power for all electrical equipment.

When all preparations had been made, the sinking unit was warped out into its approximate position over the trench in the bottom of the river. With the tunnel element only a few feet from its final alignment, the sinking operation began adding about 400 to 500 tons of water and gradually slacking off the supporting cables. When the element had reached the bottom of the trench, it was aligned to within an inch or an inch and a half of its final resting place and the entire weight was taken up on the four hydraulic jacks resting on the temporary foundation blocks which had settled onto gravel pads previously placed in the bottom of the trench. At this point, between 1,000 and 1,500 tons of water ballast were pumped into the element and it was left in this position for twenty-four hours in order to obtain first settlement of the gravel pad foundations so that more accurate positioning could be accomplished the following day.

The next day most of the water ballast was pumped out again and the winches picked up most of the tunnel weight, leaving only about 10 to 15 tons to be supported on each of the hydraulic jacks. This provided a firm hold on the element but permitted accurate alignment in a lateral and longitudinal direction by means of the cables strung from the element to anchors in the river bottom. Accurate vertical positioning was accomplished by means of the hydraulic jacks so that in the end, the tunnel unit was in position within ⅛-inch of its theoretical vertical and horizontal position. The vertical positioning allowed for future settlement of the gravel pads, which had been calculated prior to the placing of the element.

Fig. 15. Preparations for sinking.

At this point, the element had been aligned longitudinally to leave between 1 inch and 1½ inches between the face of the reinforced concrete collar on the previously-positioned unit and the rubber gasket on the face of the collar of the element being placed. The gasket was brought into contact with the face of the adjacent concrete collar by means of the 150-ton hydraulically-operated hook, previously mentioned, which was engaged with the eye in the other element. As the full load was brought to bear on this hook, a firm connection was established between the gasket and the face of the element.

Once preliminary contact had been made between the two concrete collars, the water was bled from the space between the two bulkheads. As the water pressure inside the joint chamber was released, the full hydrostatic pressure on the free end of the element (about 3,000 tons) was no longer counterbalanced and forced the two units tightly together, effecting a complete seal of the joint.

Sand Jetting

As soon as practicable after making the temporary joint between the elements, sand was jetted between the river bed and the bottom of the unit. It is necessary to give complete support to the element in order to prevent the development of any extraordinary stresses in the unit such as would be caused by large void spaces beneath it. The sand was jetted beneath the element by means of a special gantry, pipe and nozzle arrangement. Sand was drawn from a scow moored near the jetting gantry, mixed with water, pumped through the pipe system and forced out through the nozzle into place under the element. From the 25 ft. pipe extending under the element, it was possible to jet sand under half the element from either side in longitudinal strips below the unit, the gantry being moved and the nozzle rotated as the work progressed to pack solidly all the space between the element and the river bottom.

Once the sand-jetting had been completed, the hydraulic jacks were released from their load and the entire weight of the element was carried by the sand. Then started the backfilling of the trench around the element and the installation of extensive protective works, as described in the paper on hydraulic studies and bed protection.

After a reasonable time for settlement of the tunnel units, work started on completion of the joint between units. This was effected by joining up and welding the steel plates forming the waterproofing at the joints, joining and welding the reinforcing steel, and completing the concrete for the walls, floor and roof.

At the time of writing, all tunnel elements have been placed, the backfilling and bed protection have been completed, and the joints between the elements have been finished. All that remains is the installation of the very complex mechanical and electrical equipment and controls required for the operation of the tunnel. The tunnel will be ready for opening in the Spring of 1959.

NEW LABORATORIES

of

THE PULP AND PAPER RESEARCH INSTITUTE OF CANADA

THE PULP AND PAPER Research Institute of Canada is supported jointly by the Federal Government, the pulp and paper industry, and McGill University, in Montreal. The two main functions of the Research Institute are to supplement the research carried out by individual companies in the industry, by acting as a fundamental research centre, and to train students whose advanced work in science and engineering is related to the industry. Research projects are carried out at the request of members of the pulp and paper and allied industries; facilities are available for non-routine tests and measurements required by industry; and a vast amount of technical and scientific information is gathered and distributed on an international scale.

The present organization developed from a branch of the Forest Products Laboratories of Canada, in 1913, and was housed in part of two old buildings at 3420 University Street, Montreal, at the south-east corner of the McGill campus. It became a joint enterprise in 1920, when the research activities of the Canadian Pulp and Paper Association were linked with McGill and the Government, and soon outgrew its facilities. The old buildings were demolished in 1927 and the present building on the same site was officially opened in 1929.

The work continued to develop, and during World War II included extensive research for the Government. In 1950, the program was extended and the Research Institute was reorganized as a non-profit corporation under Federal charter with a board of directors and a full time management. Dr. Lincoln R. Thiesmeyer has been president, and a director, since 1950. Subsequently, financial support was ensured through renewable contracts with sustaining members of the pulp and paper industry.

Soon after 1950 the operation had extended into other buildings, and the need for a larger, centralized headquarters was apparent. By 1955, plans for a new centre were made, and the Government had agreed to build and equip the new facilities at Pointe Claire, about 15 miles west of Montreal. The building was first occupied late in 1957 and was officially opened 18th September, 1958.

The new building, which is the main subject of this article, is the administrative headquarters of the organization and houses most of the research facilities of the Institute. However, the original site in Montreal is still in operation.

Work at McGill

In the Montreal University Street building, work continues on the postgraduate student program, together with some fundamental bench-type research and chemical engineering activity. The main library is also situated there.

The Physical Chemistry Division has equipment for X-ray diffraction measurements, radioactive counting, light-scattering, for molecular weight determination, a unique couette device for measuring the flexibility of fibres, and equipment for the study of macromolecules.

For the graduate research program, facilities include radio-tracer equipment for particle velocity determination; a hot-wire anemometer for gas-flow characterization; high-speed cinephotography; and a pilot plant for investigation of flash evaporation, fluidization, and particle technology.

Engineering Development

One of the principal engineering developments in recent years has been the Atomized Suspension Technique for treating waste fluids, which will be dealt with in more detail later in this article. Three pilot plant reactors are installed in the McGill campus building.

Comprehensive modern equipment is also available for viscosity and osmotic pressure determination, electrophoresis, paper- and column-chromatography, ultra-violet apparatus, and so on.

The new Building

The new building at Pointe Claire stands on a 90-acre tract of open land owned by the Institute. Cost of the building and equipment, contributed by the Federal Government, was two and a quarter million dollars, and the industry has provided apparatus and equipment worth a further half-million dollars.

Building Design

The building was designed with a view to the possibility of future expansion of any major section without interfering with any other part. The result is a structure of four two-storey wings joined at right angles to one another, with an adjoining single-storey wing housing the service departments. This arrangement allows the main departments to be extended vertically or horizontally, and the surrounding site is sufficienly large to accommodate any expansion foreseen at present.

The structural steel frame is fairly conventional, and floors are of concrete slab construction, designed for live loads of 100 pounds per square foot in the laboratories and considerably higher loads in the engineering areas.

The design of the foundations of the administration and laboratory wings is such that basements can be added by knocking out temporary walls at either end and removing the backfill which was placed in the excavation to prevent flooding. This plan provides for an economical extension of space if and when the municipality installs storm sewers.

Crawl space is provided beneath the other wings, and utility services are generally routed along corridors where there is convenient access to vertical service ducts.

The main electrical sub-station consists of a bank of three 500kva transformers which reduce the 12,000 volts supply to 600 volts. Distribution throughout the plant is at 550 volts, with inside dry type transformers being used at convenient locations for reduction to 110-220 volts. In a number of locations duct-covered bus bars carry the 550 volts, and access is through plug-in access doors. This provides for a very flexible arrangement, and enables the staff to carry out extensive rearrangement of heavy equipment with a minimum of disruption. Machines may be connected directly to the bus bars, or inside transformers may be plugged in to give lower voltage where required.

Heating is by forced hot water, which is circulated at 200-240 degrees Fahrenheit. The present heating installation consists of two 200 h.p. units for building heat and one 40 h.p. unit for domestic hot water.

Many of the process operations of the Institute require steam, and it is provided by a single 30 h.p. electrode-type electric steam generator. This unit allows considerable variation in pressure and demand, and was chosen partly for its versatility in this regard.

Conventional lighting is used throughout the building, the three main types being fluorescent, incandescent and mercury-arc. The intensity of lighting is good and lies in the range of 40-50 lumens at desk level.

The majority of the laboratory area is force ventilated, with exhaust through fume hoods on the roof. Of special interest are two experimental rooms, one of which provides for a relative humidity range from 10% to 90% at 73°F, and the other which provides for a temperature range of 55°F to 90°F at 50% relative humidity. These experimental rooms are serviced by unit air conditioners located in a service room adjacent to the laboratories.

The building is not equipped with automatic sprinklers, but uses a variety of commercial fire extinguishers selected for their suitability in handling the many different types of fire hazards which exist.

General Layout

The main entrance leads into the administrative wing, with offices, branch library, and printing and duplicating shop on the first floor. Above this are the executive offices, drafting and editorial services, and a woodlands research conference room.

The adjoining wing, at right angles, contains facilities for the physics, chemistry, and woodlands research departments. Extending from the end of this wing is a narrower one, leading to the services annex, and to which is attached the fourth, and shortest wing, housing the mechanical engineering development department, chemical pulping plant, refiner deck and stock preparation room, and the bleaching and small-scale pulping laboratory.

The service wing contains the boiler plant, machine shop, stores, and shops for pipefitting, sheet-metal work, and wood-working. A considerable amount of equipment is designed and built by the Research Institute, and the machine shop is very well equipped and capable of handling work to very fine tolerances.

Fields of Research

Briefly, the Research Institute is capable of dealing with problems affecting the pulp and paper industry from tree growth and nutrition to processing techniques and the development of processing equipment.

This involves fundamental research, which adds to the basic knowledge of many subjects and may lead to future developments, and current work on practical problems such as the life of

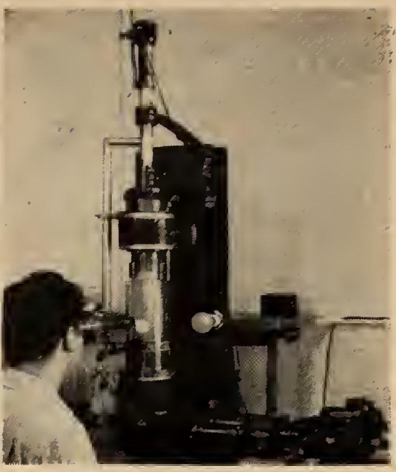


Fig. 1. Twin Couette apparatus for studying the hydrodynamic behaviour of fibres in liquids, and the flexibility and shear strength of wood pulp fibres.

paper machine wires, corrosion of digesters, power consumption for grinding processes, improvement of pulping processes, and so on. Some of these contributions to the operations of the industry will be discussed later.

Chemical Pulping

Many advances have been made in the chemical pulping field as the result of work done at the Research Institute. Much of the equipment of this department was designed at the Institute and includes four 2 cu. ft. pilot-scale digesters with preheating equipment and control of temperature, pressure, and pH. For preliminary investigations the Institute designed a microdigester which duplicates pilot-scale experiments on a small scale.

Pressure equipment includes two types of bomb digester. In one, chips are sealed in a heavy steel bomb which is heated by oil; the other version consists of a bomb which can be rotated above gas jets.

The main laboratory-scale equipment is completed by a bleaching plant and a precision guillotine chipper.

Wood chips for experimental purposes are stored in a special cold room and are sealed in plastic bags to retain the original moisture content.

Mechanical Engineering

The principal piece of equipment used for research into mechanical operations is a mill-scale 36-inch Bauer double-disk refiner. With an operating range of 600-1200 r.p.m., the refiner has a variable-speed feed belt and a capacity of 1-50 air-dry tons a day.

The department also has a Sprout-

Waldron stainless steel laboratory screen.

Physical Testing

Some interesting equipment has been designed and installed for physical testing and measurement. An Instron tester is used to measure the tensile strengh of fibres and cross-sections of wood. These can also be studied on a Vickers inverted projection microscope, which projects an image of the material on to a large inspection screen.

Designed at the Institute, and named after S. M. Chapman who developed them, are a smoothness tester for measuring smoothness of paper under printing pressures, and an electronic dirt counter. The latter looks something like a record-player turn-table and pickup; the paper sample is mounted on the rotating turntable and the 'pickup arm' has a photo-electric device in the head which scans the paper sample and automatically counts the contained specks of dirt.

Associated with this section is a special laboratory in which various controlled conditions of temperature and humidity can be maintained.

Another important piece of equipment is a scanning electron microscope which operates at magnifications up to 100,000 times. This is the first commercial prototype of an instrument developed at Cambridge University for making electron photomicrographs of wood fibres and similar materials. The scanning principle prevents the fibres from being burned during exposure.

Other Equipment

Among other specialized equipment used in the laboratories are two items which were originally developed by the Research Institute. A micocuvette uses ultra-violet absorption for the continuous measurement of lignin and other organic material in cooking liquors during chemical pulping. Also for use during cooking cycles is a special reference electrode with which continuous, high-temperature measurement of liquor pH can be made.

Photography and photomicrogaphy play a large part in the work of the Institute, and various forms of equipment are in use. The new photographic darkroom is comprehensively equipped and incorporates accurate temperature control.

Wood-Chip Slurries

One of the current fields of investigation which may be of particular interest to engineers is the hydraulic transport of wood-chips through pipelines, in the form of a slurry with water.

This work is still in the early stages, but a 528-ft. loop of 8-inch aluminum pipe has recently been installed, together with the associated auxiliary pumping equipment, for the study of this subject.

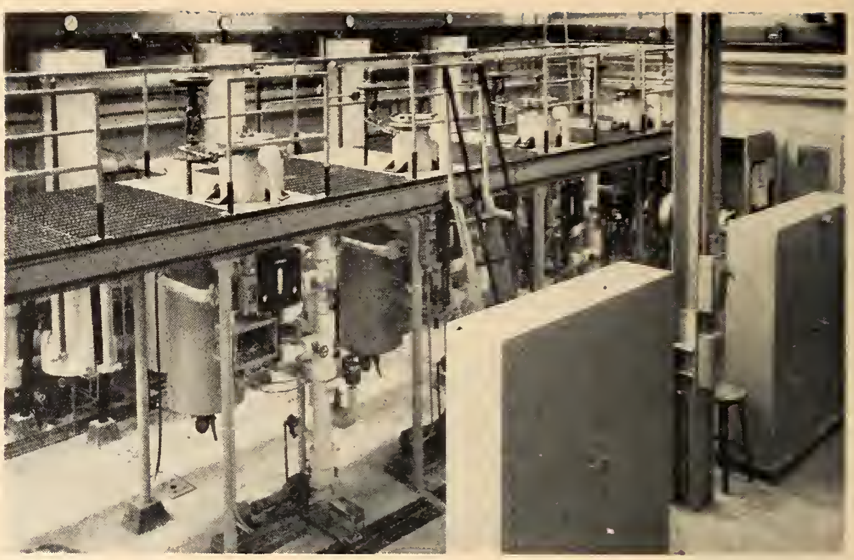


Fig. 2. 2 cu. ft. digesters used in pilot-scale studies of chemical pulping processes.

Atomized Suspension Technique

A development which promises to have far-reaching applications even beyond the pulp and paper industry is known as the Atomized Suspension Technique (AST). This was developed by Dr. W. H. Gauvin M.E.I.C., now head of the chemical engineering division of the Pulp and Paper Research Institute of Canada.

The AST has emerged from an original study of the possibility of recovering sulphur from waste sulphite liquors made during a severe sulphur shortage during 1951. There is no longer a shortage of sulphur, but the study has proved to be of great significance, and the technique has been patented.

Experimental Equipment

There are three pilot-plant AST reactors at the Research Institute building in Montreal, all of stainless steel construction. One is 8 in. i.d. by 10 ft. high; one is 12 in. i.d. by 15 ft. high; and the third, specially built for sludge treatment, is 5 ft. i.d. by 7 ft. high.

The results of three pilot-scale investigations are briefly described here.

Sulphite Waste—

The treatment of neutral sulphite semi-chemical liquors, in the 8-in. diameter reactor, gave a solid residue of sodium carbonate and sodium sulphate, steam, and a mixture of gases, particularly hydrogen, carbon dioxide, and methane. Results indicated that the technique might form the basis of a promising recovery process.

Sanitary Sludges—

From investigations into sewage sludges it was shown that these can be destroyed rapidly and continuously under atmospheric pressure. Low capital and operating costs are foreseen, and maintenance should be simple. Heating may be electrical or by oil, city gas, natural gas, or even waste flue gas. The first municipal-scale plant has now been built at Beaconsfield, Que., not far from the Pointe Claire headquarters of the Research Institute. For convenience, this plant is designed for electrical heating.

Refinery Effluents—

An aqueous refinery oil sludge was processed in the 8-in. reactor to determine if it could be separated into disposable or re-usable components. The products were steam, an essentially inorganic residue, a gas of excellent calorific value, and small amounts of oil.

Other Research Applications

The Atomized Suspension Technique is a particularly prominent example of the practical achievements resulting from the work of the Pulp and Paper Research Institute of Canada. Though there may be no other immediately apparent single comparable development, the work of the Institute over the years has had a considerable influence on the operations of the industry. In general this has amounted to an improvement in techniques and efficiencies of operation which has helped to keep the industry to the fore.

Woodlands Research

The growing and harvesting of woods and the development of improved species are regarded as a part of the overall manufacturing industry. Research into woodlands problems must be related to possible effects on mill practice.

The Woodlands Research Division is studying the nutrition of pulpwood species in the new laboratories at Pointe Claire, under controlled atmospheric and other conditions.

One current project is to evaluate a hybrid poplar grown by one of the paper companies. In addition to woodlands research the investigating team is concerned with grinding, chemical pulping, bleaching, physical and chemical testing of pulp, and the study of fibre characteristics.

Wire Life Study

In 1956 an investigation was started at the Institute, at the request of the newsprint industry, to find the causes of the short life of paper machine wires, which may be as little as four or five days. To study even the most likely of the many possible causes would be a long and costly process for the industry.

A research team with varied training and experience studied the problem in several mills and were able to select the most significant variables. These are: the drag load of the wire over the suction boxes; grit concentration in the headbox stock; wire speed, mesh, and length; and angle of wrap of the wire on the wash roll. Many of the findings can be applied immediately by the mills, and if any further research is indicated it can be restricted to these six variables.

Digester Corrosion

An earlier study by the Institute, in 1950, into the rapid corrosion of alkaline digesters was also directed at finding the principal causes from a large number of possible variables. The causes of both general surface attack and the more serious rapid local corrosion were found, and further work has resulted in the development of anodic protection against corrosion. This technique is being studied commercially in a pulp mill, following preliminary trials, and a commercial firm has been granted patent rights with a view to marketing the technique.

Power for Grinding

Although the Canadian newsprint industry, the largest supplier in the world, is fortunate in having cheap hydro-electric power and abundant softwood supplies, great economies could be achieved by only a small saving in the vast amounts of power required to produce groundwood, the principal component in newsprint. It is estimated that over 99 per cent of the power used is wasted in the form of heat.

The Institute has been engaged in a study of the mechanism of fibre-removal from wood by grinding. One of the findings has been that some deformation of the wood is necessary for fibre removal, but, at present, much grinding energy is needlessly used in repeated deformation of the fibrous structure by the grits in the stone. Further understanding of the fundamental process of fibre removal will doubtless produce results of value to this important section of the industry.

Fig. 3. A mill-scale 36-in. double-disc refiner, part of the complement of equipment for research in mechanical operations.

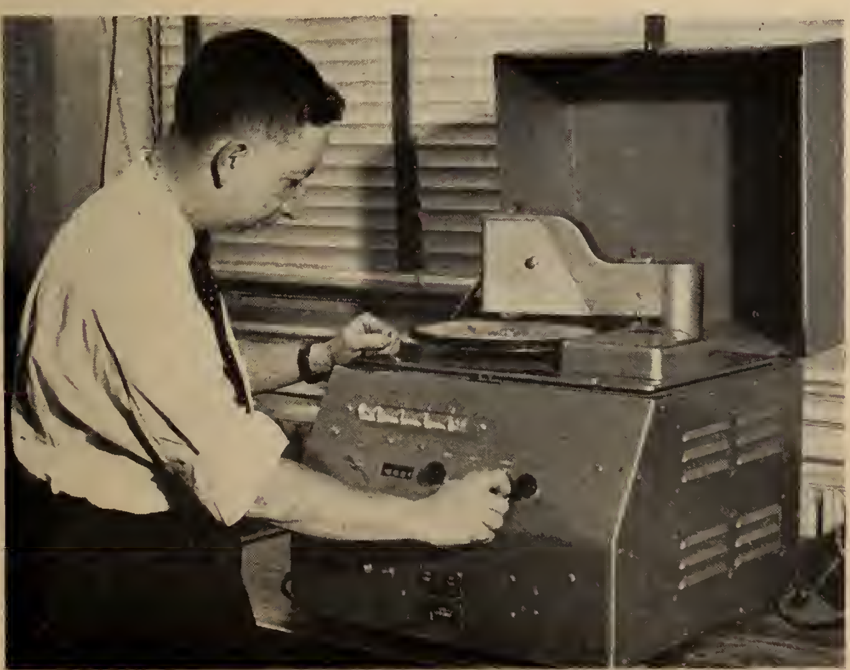


Fig. 4. The Electronic Dirt Counter. Paper sample rotates on turntable, is scanned photoelectrically, and dirt specks are counted electronically.

Pulpwood Holding Grounds

In 1952 the Institute was asked by the industry to investigate the problem of the forces existing in pulpwood holding grounds. This work has been under the supervision of Prof. R. J. Kennedy, M.E.I.C., of Queen's University, Kingston, Ont., and the first phase of the project was covered by a report published in *The Engineering Journal* (1958, January, p. 58).

A survey was made of installations and practice in eastern Canada, leading to a combined laboratory and field investigation. Methods of calculating the total force exerted by the water on the wood in a transverse holding ground, and the division of the force between the sjores and the boom system, were developed.

Fundamental Research

One of the most important functions of the Institute is to act as fundamental research centre for the Canadian pulp and paper industry. In this it supplements the various research organisations of individual companies.

Fundamental research is carried

out on a wide number of fronts each attempting to contribute to a broad background of theoretical knowledge from which the various problems arising in the manufacture of pulp and paper can be attacked.

It would be impossible to list here the multiplicity of fundamental projects currently active. A few well-spaced examples, however, will give an idea of the scope and variety of the program and of the way in which basic research is related to technological requirements.

Intensive investigations are being conducted in the Physical Chemistry Division into the hydrodynamic properties of pulp fibres in suspensions. The tendency of these fibres to flocculate results in unique flow characteristics which were, until recently, little understood, and which affect strongly not only the behaviour of the pulp throughout the entire paper-making cycle, but the quality of the finished sheet. Relating these fundamental properties to the properties of the sheet, can result in improved machine design and ultimately a better product.

The lignin macromolecule is undergoing special study. This complex and as yet imperfectly-understood substance is the chemical binding agent in wood, and further understanding of its colloidal and polymoric properties will contribute not only towards improved and more economical chemical pulping processes, but in the exploration of various possibilities of commercial lignin utilisation. Such basic studies of lignin and its derivatives has already suggested an increasing variety of technological applications of it as a dispersive alloid.

Related fundamental studies in the Division of Wood Chemistry are concerned chiefly with lignin's chemical structure and behaviour, with special regard to technical pulping and bleaching processes. Current pulping methods are so drastic that they destroy about one-fifth of the usable cellulose in the wood and reduce the viscosity of the remainder. It has been found in the laboratory that excellent pulp can be produced in a few seconds, a finding that may lead, after considerable development work, to high speed continuous pulping on a commercial scale.

Also having an important part in the basic research program are fundamental studies in mechanical pulping. Investigations are being pushed ahead into such fundamentals as stress-relaxation, in wood, the mechanical response of fibres to impact, energy loss during the deformation of a viscoelastic material—all of which have an important theoretical bearing on the mechanics of groundwood production and which could lead to new and more efficient mechanical pulping methods with higher output and less energy consumption.

In chemical engineering, basic studies are chiefly concerned with the technology and fundamental properties of droplets, small particles and finely-divided systems of various kinds. It was from research of this kind that the Atomized Suspension Technique described earlier was evolved.

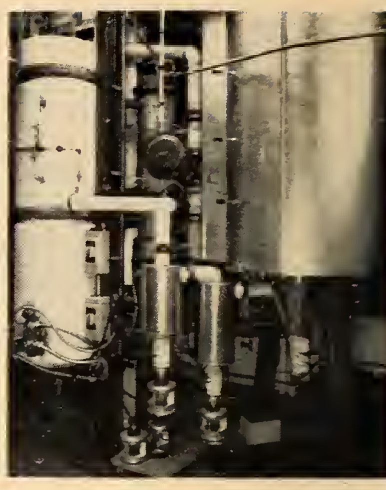
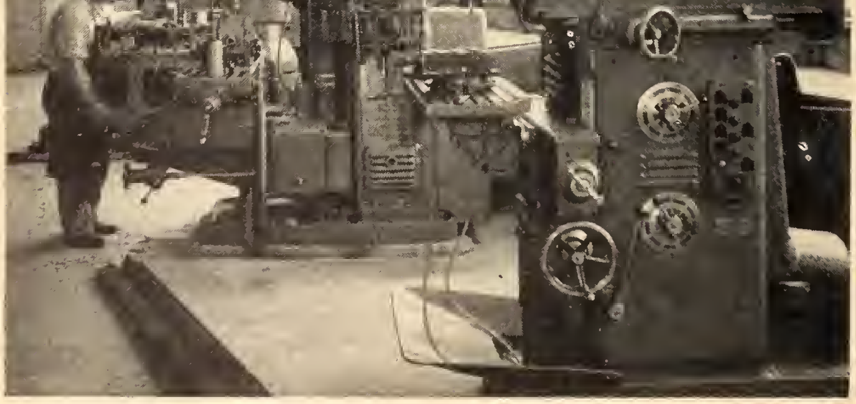


Fig. 5. Pilot-scale reactor for study of the Atomized Suspension Technique for chemical processing, newly-developed by the Institute.

Fig. 6. Part of the well-equipped machine shop; an indispensable part of the research establishment. The Institute designs and builds much of its own equipment.



Some fundamental projects are carried out at a staff level, others by McGill University graduate students working toward doctoral degrees. Some are undertaken in the study of problems currently existing in the industry, others although their potential range of industrial significance is known, await direct application.

The pre-doctoral students participating in the basic research program are directly supervised by Institute scientific staff members who hold concurrent teaching posts at the University. Although most of the 250 who have so far participated have been organic and physical chemists with some chemical and mechanical engineers, the Institute hopes to broaden its area of co-operation with the University to include a wider variety of scientific disciplines such as metallurgy, pure physics, biology, biochemistry, and the new borderline science of biophysics.

Conclusion

The position to which the Canadian pulp and paper industry has advanced has been achieved through the joint efforts of researchers and operators within that industry and in others which supply raw materials and equipment.

The part played by the Pulp and Paper Research Institute of Canada is no small one, and it may well be greater yet as the Institute operates from its new headquarters and laboratories.

THE FREE PISTON ENGINE

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BY DEFINITION, a free piston engine is one in which the movement of the pistons is controlled by the combustion and gas pressures instead of being confined to the repetition of a pre-determined motion governed by a mechanical linkage.

The free piston principle is as old as the gas engine and the first practicable engine developed by *Barsanti & Matteuci* in 1859 was essentially a free piston engine and was so described by its inventors. This engine was improved and put into commercial production by *Otto & Langdon*, who exhibited the engine at the 1867 International Exposition in Paris.

In this engine the piston operated in a vertical cylinder with the cylinder head at the base. The expanding products of combustion expelled the piston up the open cylinder. The stroke was limited only by gravity, friction and atmospheric pressure and the piston was returned to the firing position by gravity, assisted by the depression under the piston at maximum stroke and atmospheric pressure acting on the upper side. The energy in the falling piston was absorbed by rotating a shaft.

A modern diesel pile-driver operates on this same principle, but the energy of the falling piston is transmitted directly to the head of the pile supporting the cylinder head.

The *Humphrey* pump which was developed in 1906 is also an internal combustion free piston engine in which a column of water is substituted for the piston.

There are several well known boiler feed pumps and steam driven air compressors which are free piston machines. Although all these types are true free piston engines in that the stroke is un-confined by any mechanical linkage, in each case they are characterized by the use of only one piston, which in the internal combustion application is returned by gravity.

The free piston engines which are the subject of this paper are essentially different from the foregoing in that the piston is controlled and returned by gas or air pressure acting on the end of the piston remote from the combustion chamber. In practice this type of engine invariably uses two pistons operating in opposition with a common combustion chamber interposed between the two piston crowns; it has been the subject of commercial development since 1922.

Early Development

The development of gas generators can be traced back to the early work on turbo-charging by Dr. Buchi which has resulted in recent years in the development of the compound cycle in which mechanical power is taken off both a crankshaft and an exhaust gas turbine forming parts of the same system.

The free piston gasifier, however, owes its origin to *Pescara,* who built several types of free piston air compressor in the 1920's, the gasifier being a natural development from the free piston compressor, and a 950 kw free piston generating set was in operation in 1939.

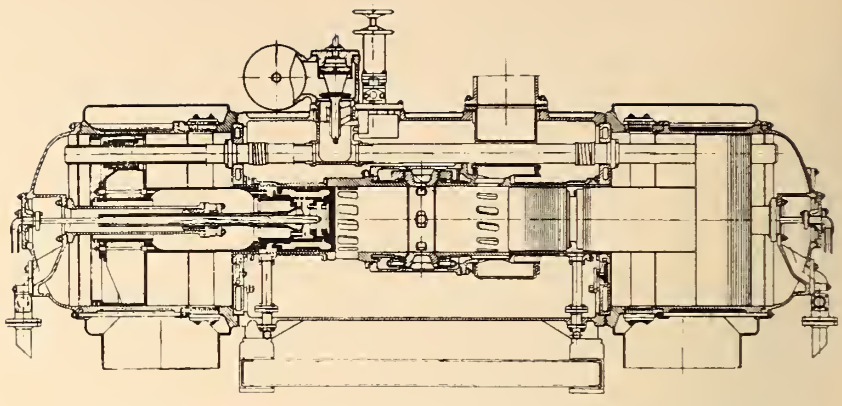


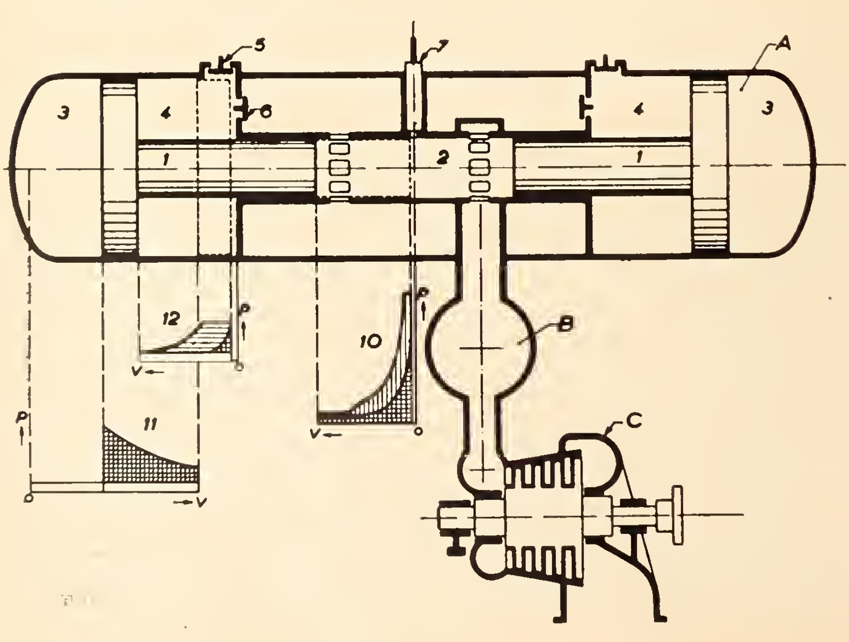
Fig. 1. Longitudinal section of GS. 34 Gas Generator 1250 gas H.P.

A prototype of the present 1250 GHP GS 34 unit was built in 1944, has been under continuous development since that time, and is now in regular production in both France and England.

In 1942 the Royal Navy initiated development of a smaller free piston gasifier of higher speed. This work was carried out at the Admiralty Engineering Laboratory in England, in conjunction with Alan Muntz. The latter have since continued the commercial development of this machine as the CS. 75.

An internal combustion engine can be considered to be a heat engine using air as the working medium, which air is expanded under the action of heat generated by the combustion of fuel in a closed cylinder. In a conventional engine the energy is converted into useful mechanical work in course of expansion by the movement of a piston and linkages connected thereto. The free piston gasifier utilizes the same heat energy, derived from the combustion of fuel to expand air in a cylinder in a precisely similar manner save that the process can be carried out more efficiently at much higher pressures. Instead of converting the energy directly into mechanical energy through pistons anl linkages, the working fluid is ducted away from the combustion part of the cycle which takes place in the "gasifier" and mechanical energy is extracted in a separate process by expanding the heated air and combustion products through a turbine.

Fig. 2. Diagrammatic sketch of a free-piston gas generator and gas turbine, showing pressure-volume diagrams of the engine, compressor and cushion cylinders. A) gas generator; B) gas collector; C) gas turbine. 1) piston. 2) engine cylinder. 3) cushion cylinder. 4) compressor cylinder. 5) suction valves. 6) delivery valves. 7) fuel injector. 10) p-V diagram of engine cylinder. 11) p-V diagram of cushion cylinder. 12) p-V diagram of compressor cylinder.



Logical Final Stage

The free piston gasifier turbine engine has been over 30 years in gestation largely due to the fact that it is the logical final stage in the development of the diesel engine, and as such had to await until high pressure turbo-charging and B.M.E.P.'s revealed the limitations of conventional crankshafts and bearings and provided the necessary incentives for their complete elimination.

Development has been broadly upon two lines, resulting in two basic types of free piston gasifier:—

(a) The outward compressing type in which the scavenge air is compressed during the outward firing strokes of the diesel piston.

(b) The inward compressing type in which the scavenge air is compressed during the inward or compression strokes of the diesel piston.

Advantages of the Inward Compressing Principle

Although the outward compressing type appears to offer advantages arising out of the phasing of the scavenge air pressure with port opening, in practice this is more than outweighed by difficulties in disposing of surplus heat and in assuring adequate lubrication.

All gasifiers presently in commercial production are therefore, based upon the inward compressing principle which enables a very simple and robust type of construction to be adopted.

This type of free piston engine is developed as a highly supercharged, horizontally opposed-piston, two-cycle uniflow engine in which each of the opposed pistons is rigidly connected by means of a rod or trunk to a compressor or cushion piston. The outer faces of these cushion pistons operate in closed chambers in which air is compressed during the outward or firing stroke of the diesel pistons, and the energy stored in the compressed air serves as a spring and returns the piston assembly to the firing position to complete the cycle. The inner faces of the cushion pistons function as scavenge pumps and compress air into the engine case surrounding the diesel cylinder.

Designed for Maximum Efficiency

It will be seen from this that the load-carrying bearings which are a limiting feature in the development of the conventional reciprocating diesel engine, are eliminated in the free piston engine and combustion conditions can therefore, be designed for maximum efficiency. The only mechanical linkage between the pistons is a synchronizing mechanism designed to keep the two pistons in step with each other. This mechanism also drives the fuel pump and other auxiliaries.

There are two basic classes of such free piston engines in production:

(a) *Air Compressors* in which the diesel cylinder is either naturally aspirated, or carries a very nominal degree of supercharge, the exhaust being either direct to atmosphere or against the modest back pressure of an elementary form of gas turbine arranged to drive the auxiliaries.

In the *Pescara* and *Mackay* compressors one of the two diesel pistons is connected to a compressor piston by means of a piston rod, the outer face of the compressor piston being arranged to deliver compressed air for the operation of pneumatic tools, etc. The inner face acts as a scavenge pump delivering air through valves into the engine case, from where it passes through scavenge ports into the diesel cylinder. The other diesel piston is connected to a cushion piston which operates inside a closed cushion cylinder; this serves to balance the forces acting on the opposite piston and to assist the return of the combined piston assemblies to the inner dead point position after each firing stroke.

This machine is thus non-symmetrical, and unlike the free piston gasifier, is not perfectly balanced, the synchronizing linkage being designed to transmit the out-of-balance output. The out-of-balance is in fact negligible when compared with conventional machines, and the machine is vibrationless in operation.

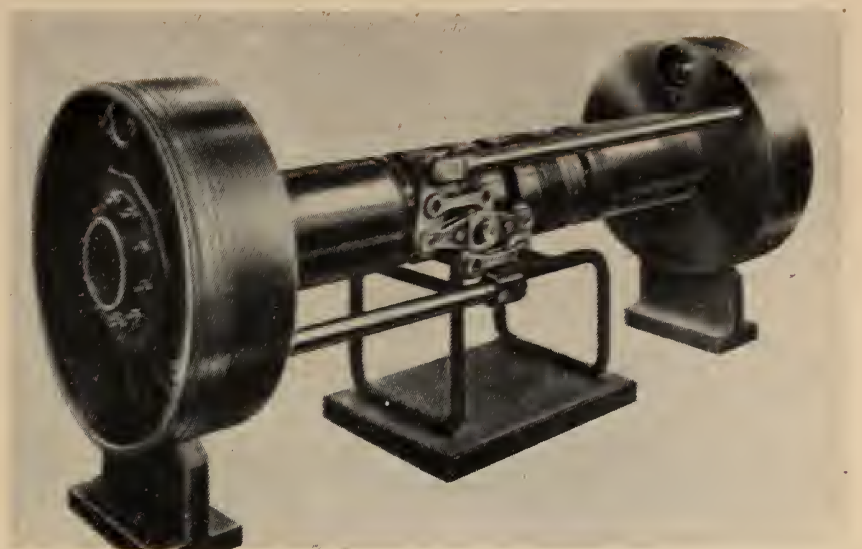


Fig. 3. Moving parts of GS. 34.

(b) The other class of free piston engine is the *Gas Generator*, or gasifier, which is of symmetrical construction, each diesel piston being rigidly connected to a cushion piston, as already described, and the entire output of the compressor cylinders is delivered to the diesel cylinder at a relatively high pressure. The air then undergoes a normal but highly supercharged diesel cycle, with combustion partly at constant volume and partly at constant pressure. The hot products of combustion are then discharged at a pressure slightly lower than that of the incoming air into a manifold connecting the gasifier to an exhaust turbine; the latter is the true prime mover.

The free piston gasifier is a logical development of the compound, turbocharged diesel cycle and is thus a very highly supercharged diesel engine. It replaces the compressor and combustion chamber of a conventional open cycle gas turbine, and operates at a much higher compression ratio and thermal efficiency than is ever likely to be obtained with an axial flow rotary compressor, or than can be usefully employed in a crankshaft engine.

Gas Thermal Efficiency

The free piston engine operates at a high thermal efficiency, the latter being defined as the work done per pound of gas delivered when expanded isentropically to atmosphere, divided by the heat input in the fuel for each pound of gas delivered. This gas thermal efficiency at the present stage of development is between 42 and 43½%, depending on the size of machine, and this, multiplied by the turbine and ducting efficiency, gives the brake thermal efficiency of the gasifier turbine combination, which is comparable with good diesel efficiencies, and nearly double that to be expected from a simple open-cycle gas turbine.

The Mechanical Features of free piston engines are characterized by a basically simple structure of generally cylindrical form, a feature which applies both to the main body of the engine and to the piston assemblies. Details of the two sizes of gasifier presently in production are shown in table I. The larger unit is designated as the GS.34 gasifier and is shown in section in Fig. 1.

Gas Load on Piston Crown

It will be seen from Fig. 2 that the loads produced by the gas pressures in the various cylinders are taken in a direct manner both in the body of the engine and by the piston assemblies. The gas load on the diesel piston crown is transmitted axially along a cylindrical trunk to the compressor piston, is absorbed by the inertia of the pistons themselves, and does not have to be transmitted through the body of the engine. Only the radial pressure loading in the combustion space has to be resisted by a hoop stress in the central zone of the diesel cylinder liner, which can be met by a very simple design. The outward momentum of the moving parts is taken by the cushion head, and as the cushion cylinder has a low ratio of maximum to minimum pressure, the maximum load to be transmitted through the body from one end of the engine to the other is relatively low.

The pistons are of generally symmetrical design as dictated by the gas loading on the piston crown. There being no wrist pin or bosses, none of the clearance or expansion problems normally associated therewith can arise. Similarly all loading is axial; there is no imposed side-thrust and the piston does not have to function as a cross-head as in the case of a conventional trunk piston engine. There being no crankcase, the danger of crankcase explosions is eliminated and the possibility of blow-by is minimized. As operating diesel engineers will know, amongst the main problems with modern highly stressed diesels are loading on the cylinder head studding and joints, and between the piston skirt and liner; the latter can be aggravated by the oil film breaking down due to the blow-by of small particles of carbon from the combustion space, or particles flung from the crankcase oil. These problems are largely eliminated in the free piston design.

Synchronizing Gear

There are the minimum number of constraints on the moving parts of a free piston machine. Each piston assembly, sliding in its respective cylinder is maintained in step with the other piston assembly by one set of synchronizing rods only. This synchronizing gear can take the form either of a lazy-tongs type of linkage as on the GS.34, a rack and pinion as on the CS.75, or a rocking lever and connecting rods as in the DAC compressor.

As has already been indicated, the synchronizing linkage is not required to transmit any load on a perfectly symmetrical engine other than that necessary to drive the fuel injection pump or other auxiliary equipment. The synchronizing linkage is therefore, made quite light not only to avoid a direct addition to the weight of the moving parts, but also because the compressor pistons themselves must be designed to carry the inertia loading produced by the synchronizing gear.

The moving parts of a 1250 GHP GS.34 gasifier are shown assembled in their firing position in Fig. 3.

The symmetrical construction of these engines makes them particularly insensitive to thermal distortions through rapid changes of load, and they can put on load from cold very rapidly. No energy is stored in the machine between cycles which therefore stops immediately fuel is cut off, and no damage can result from the dissipation of energy stored in rotating masses as is the case in conventional engines.

There is no vibration due to the reciprocating parts as the masses are made as nearly identical as is required and are in static and dynamic balance. The engines run with a remarkable absence of vibration and require virtually no foundations other than those required to support the actual static weight.

Care must, however, be taken that no extraneous vibrations are introduced by gas pulsations in the intake and delivery ducts of the machine. This can be achieved by correct design in the light of present day knowledge of gas dynamics and acoustical engineering.

The diesel cylinder discharges into a gas collector which smoothes the gas pulsations in the turbine manifold to a low value. The pressure variations in this gas collector at full load are of the order of plus and minus 4 lbs./sq. in. on a mean pressure of about 45 lbs./sq. in. The mean pressure wave has a fundamental frequency of about 10 cycles per second for the GS.34 and 18 cycles for the CS.75, and these frequencies are low enough not to constitute any hazard to the turbine blades the natural frequency of which, even in the first stage of a large turbine, is of the order of 1000 cycles per second.

Dephasing

A more constant rate of gas flow can be obtained in multiple installations by coupling gasifiers in pairs with a phase displacement of 180°. This is achieved by coupling the cushion ends of the two machines through a dephasing valve which consists essentially of a differential piston connected across the cushions which activates a valve, arranged in such a manner that cushion pressure is increased or decreased as necessary to keep the pistons displaced by half a cycle. In such a case, the engine cases would also be connected together in order to damp out cyclic fluctuations in scavenge air pressure.

A turbine constitutes an excellent silencer, and no other provision is required to silence the exhaust. The air intake casings around each compressor cylinder effectively silence the induction noise and reduce the air pulsations. The general level of noise produced by a free piston engine is somewhat less than that of a diesel engine of the same size and speed, and there is a notable absence of high frequency clatter arising from valve gear, etc. The noise level adjacent to free piston gasifiers has been measured at 95 decibels.

Characteristics

The characteristics of a free piston gas generator of the type under consideration are shown in Fig. 4. The curves, refer to the GS.34 but can be applied to the CS.75 by multiplying the speed by 1.8 and dividing the gas flow and power outputs by 3.

The speed of oscillation of a free piston engine is not an independent variable as it is on a crankshaft engine, and is principally determined by the mass of the moving parts and

Table I—Technical Data of CS. 75 and GS. 34 Gas Generators

Two types of free-piston gas-generator are at present available the GS. 34 of 1,250 gas h.p.* and the CS. 75 of 420 gas h.p. Their leading dimensions are given below:—

		GS.34	CS.75
Engine cylinder bore	in.	13.4	7.5
Comp. cylinder bore	in.	35.4	20.75
Overall length	ft.	13.75	7.5
Weight	tons	8	2.25
Stroke at continuous max. rating (C.M.R.)	in.	2 x 17.4	2 x 9.8
No. of oscillations at C.M.R.	cycles/min.	570	1,100
Mean piston speed	ft./min.	1,650	1,650
Gas temp. at C.M.R.	deg. C.	437	460
Gas pressure at C.M.R.	lb. per sq. in.	42.5	50
Mass flow of gas	lb. sec.	8.8	2.65
Gas h.p. at C.M.R.		1,250	420
Thermal efficiency into gas	%	43	42
Specific fuel consumption	lb./gas h.p. hr.	0.320	0.325
Volume compression ratio at C.M.R.		9.1	8.1
Compression pressure	lb. per sq. in.	1,000	1,000
Max. cylinder pressure	lb. per sq. in.	1,700	2,000
Heat to jacket cooling water	% heat input	14	17
Heat to piston cooling oil	% heat input	5	5

Present ratings of free-piston engines consisting of one gas-generator coupled to a turbine, with reduction gearing, are 1,000 shaft h.p. for the GS. 34 gas-generator, and 350 shaft h.p. for the CS. 75 gas-generator.

*The output of a gas-generator is usually expressed as "Gas h.p." This is defined as the power available from an adiabatic expansion of the gas down to atmospheric pressure.

the gas delivery pressure, and only to a secondary extent by other operating conditions such as the load and length of stroke.

The motion of the pistons is analogous to that of a weight on the end of a spring. In each case the frequency is determined by the effective stiffness of the restoring force. In the free piston engine, this stiffness is determined by the gas pressure in the various cylinders and it has an approximately constant value at any gas delivery pressure and increases with it.

As the frequency is proportional to the square root of the stiffness, the extreme range of speed from no load to full load is limited to less than two to one. This is because the stiffness due to the gas pressure varies over a range of less than four to one, which is approximately the range of the absolute pressure of gas delivery.

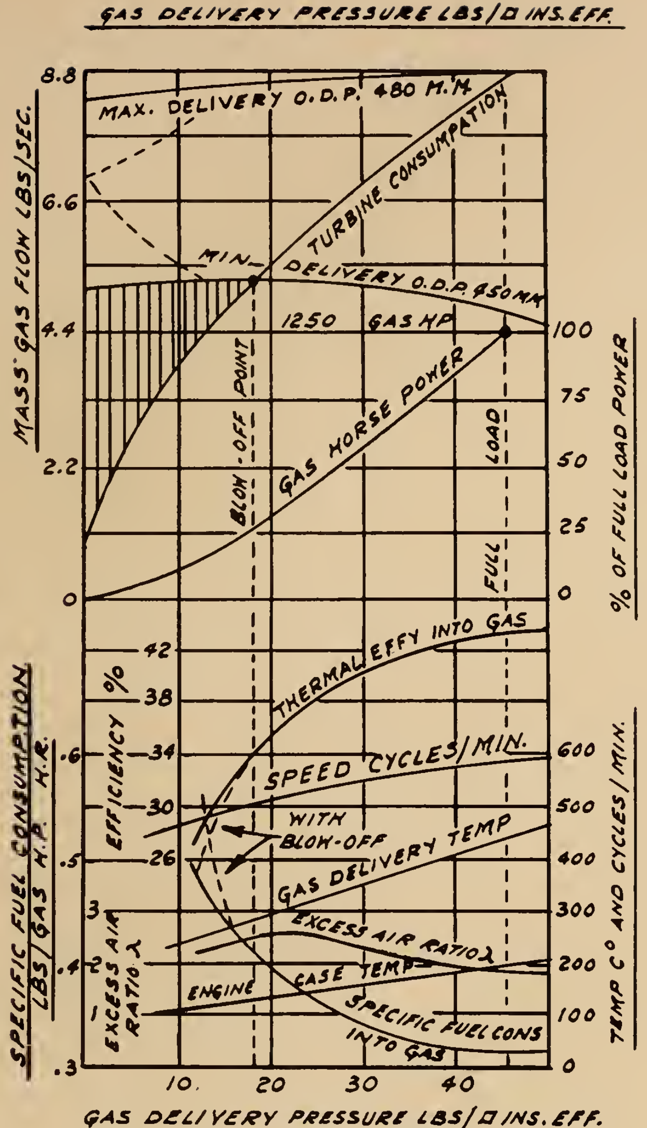


Fig. 4. Characteristics of GS. 34 gasifier.

Power Output

Basically, the power output is controlled by adjusting the fuel admitted which has the effect of varying the stroke, thereby altering the mass flow of gas. In the normal arrangement where a gasifier supplies a turbine, any increase in gas flow results in an increase of delivery pressure since the turbine behaves substantially as an orifice of constant area. At the same time the gas delivery temperature rises because of the increased work of compression.

The power output is proportional to the mass gas flow, the absolute temperature and the isentropic drop ratio, the latter increasing with the pressure ratio. Thus the combined effect of the three dependent variables is that the power varies over a wide range for quite a small change of stroke. For example, a drop in power of 75% from 100% to 25% is produced by a reduction in stroke of only about 20%. This effect is enhanced by the relatively large clearance volume in the compressor cylinder, which means that the percentage change in the delivery is greater than the percentage change in the rate of stroke.

Recirculation

The minimum permissible stroke is governed by the necessity of uncovering the scavenge ports, and which, in turn, determines the amount of fuel required when idling. This is compensated for and the part load performance and fuel consumption improved, by a system of "recirculation" whereby hot, compressed air from the engine case is fed back to the compressor intake. This has the effect of reducing the compression ratio and increasing the clearance volumes in the compressor ends, thereby reducing both the compressor deliveries and the cushion pressures, and which in turn slows down the speed of oscillation and reduces the mass gas flow to closely match the requirements of the turbine characteristics at part loads.

A by-pass valve may be also connected to pass some of the scavenge air direct from the engine case to the gas collector at low loads when there is more air available than is required to scavenge the diesel cylinder. This reduces the pressure drop across the diesel cylinder ports and reduces the pumping losses, which is reflected in further fuel economies. The mass gas flow can also be matched to turbine demand at light loads by throttling the compressor intakes.

A gas blow-off is provided to enable the gasifier to idle against a stopped turbine and to facilitate the starting up of gas generators in multiple installations, whilst others are already running on load.

The blow-off valve is customarily combined with a stop valve used to isolate the gasifier from the common manifold used in a multiple installation. This combination valve may be directly operated by the turbine actuated governor, and in the case of an electric generating set, an overriding servo valve may be directly operated by the main circuit breaker, which would take charge in the event of a sudden loss of load.

Stability

Stability is a function of the mean cushion pressure, which must be adjusted to suit the actual working pressure at the turbine stop valve in order to maintain suitable compression pressures in the diesel cylinder. The engine case pressure may be regarded as constant for any given load whereas the air in the cushion cylinder is compressed to several atmospheres and expanded again in course of each stroke. Thus for one part of the inward end of the stroke the cushion pressure is below that of the engine case whilst at the other it is above engine case pressure. Thus it is always possible to transfer air from the cushion cylinders to the engine case during one part of each stroke or from the engine case to the cushions during the other part of the stroke. Advantage is taken of this to automatically adjust cushion pressures by the use of a stabilizing valve between the balance pipe joining the cushions and the engine case. A spring-loaded differential piston, sensitive to the pressure differential between the cushion balance pipe and the engine case, is arranged to operate a piston valve which transfers air in either direction as required to compensate for changes in engine case pressure; which pressure is in turn controlled by the load demand on the turbines.

Fuel Injection

Fuel injection has to meet conditions peculiar to the free piston engine in that injection takes place over a period which includes inner dead centre when the pistons and all parts connected to them are stationary and there is no energy to continue the cycle other than that to be obtained from the combustion of fuel. Fuel injection in the GS.34 is, therefore, affected by means of an accumulator operated pump whereby fuel is metered and stored under pressure in a chamber which is vented to the injectors at a pre-arranged time, controlled by the delivery pressure, just before the inner dead point is reached. The fuel is expelled through the injectors by air pressure acting on the accumulator chamber. The injection operation is a function of the air pressure, fuel quantity and nozzle area, and is entirely independent of the pistons once the cycle has been commenced. The type of accumulator pump used in the GS.34 is illustrated in Fig. 5. Higher speed machines such as the DAC Air Compressor can use conventional injection pumps with mechanical delay. Controls are very simple and are centralized in a single hand wheel, the operation of which starts the set, governs its operation and shuts it down.

Initial movement of the wheel to the starting position admits air under pressure to a small, pneumatic cylinder which moves the pistons apart to their outer dead points. A "shot" of air is then admitted to the cushion cylinders, which serves to throw the two pistons together at full operating speed, raising the temperature of the entrapped air until the combustion of fuel causes the pistons to move apart and the machine is operating. Control of the set is then taken over by the hydraulic governing system operated by the power turbine energized by the gasifier. The air requirement for starting is very modest and of the order of 10 to 12 cubic feet.

The gasifier is stopped by cutting off the supply of fuel, either by means of the governor or by movement of the control wheel. Fuel may also be cut off by a simple mechanical over-stroke trip which is operated from the linkage in the event of the O.D.P. exceeding a safe limit, and by an overspeed trip on the turbine shaft connected to the same device. In the case of Marine applications of a type utilizing a unidirectional turbine with variable pitch propellers a single control can be arranged to co-ordinate turbine output with propeller pitch.

Performance and Economic Considerations

As has already been indicated, the thermal efficiency of converting fuel into gas is high, and is approximately 43% for the gas conditions which are now customary.

Losses are involved in converting the gas energy into mechanical energy, and typical figures are 1½% to 2% for pipe friction losses, etc., in the manifolding, and 1½% to 3% in the reduction gear, if used.

Turbine efficiencies vary with type and efficiencies of the order of 87% to better than 89% are obtainable with multistage axial flow turbines. Such efficiencies make possible an overall fuel consumption on heavy fuel better than .4 lbs./SHP /hour. Economies in weight and space, can be obtained by using small lightweight turbines running at speeds of the order of 30,000 RPM and upward and for some applications simple radial inwards flow turbines have advantages. Fig. 6 shows a 200 kw D.C. Marine auxiliary generator driven by a high-speed three stage axial flow turbine operating at 29,000 RPM and energized by a CS.75 gasifier.

The conversion losses are largely compensated for by a reduction of other losses. In a conventional engine,

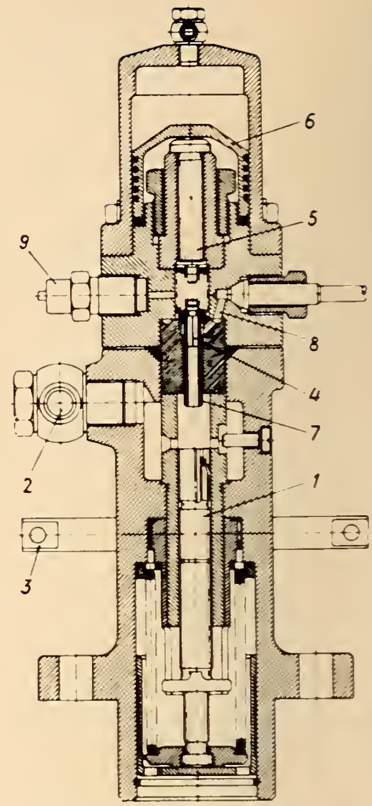


Fig. 5. Fuel accumulator pump (scale 1:5). 1) metering pump. 2) suction connection. 3) control rack. 4) non-return valve. 5) accumulator plunger. 6) air pressure plunger. 7) delivery valve. 8) fuel injection pipe. 9) safety valve.

as much as 25% of the mechanical power generated may be lost in overcoming friction, rather more than half of this being accounted for by bearing friction and windage, which is entirely eliminated in the free piston engine. According to tests carried out at the *Technical Hochschule* in Zurich (Eichelberg) the friction losses in a free piston engine amount to only 9.3% of the effective turbine output.

Comparable Heat Losses

The heat loss to the water jackets in a conventional engine can amount to 25% and an additional 6% or 7% may be lost through the lubricating oil. The heat losses in a comparable free piston engine approximate 19%, made up of 14% to the water jacket and 5% to the piston cooling oil.

It will be apparent from the foregoing that the overall efficiency of the gasifier and turbine is comparable with that of a modern high efficiency diesel engine operating at a thermal efficiency of the order of 37%.

The gasifier and turbine enjoy several advantages, particularly the ability to burn a very wide range of fuels, and in fact, the gasifier can be operated on anything from residual fuel and bunker "C" to kerosene and gasoline, the power output being directly proportional to the calorific value of the fuel used.

The gas in the manifold before the turbine stop valve contains approximately 80% unburned air, and advantage of this can be taken to burn additional fuel before the turbine, which has the effect of raising the gas temperature and increasing the mechanical output by some 40%. This feature can be usefully employed to temporarily increase the power output to meet peak loadings in certain applications, as for instance, traction, at the expense of a temporary reduction in thermal efficiency. The higher temperature levels will, however, necessitate a more expensive type of turbine blading.

The free piston engine and turbine being vibrationless, do not require massive foundations and the units, being comparatively small, do not call for heavy structural members or gantrycranes for maintenance purposes.

The power weight ratio and volume area occupied by an installation of given power compares favourably with other types of prime mover, and the fact that the gasifiers do not have to be in any particular alignment with the output shaft has advantages, particularly for marine propulsion and locomotive installations.

The cooling water requirement is low and is of the order of 7 gallons per installed horsepower per hour. The possibility of recovering heat from the turbine exhaust is of interest in some applications, as for instance, in the case of Heat pumps for space heating, and for the generation of hot water or steam.

Maintenance

Maintenance is very low due to the small number of moving parts and compares very favourably with other types of prime mover. Due to the use of low temperatures and pressures there is no corrosion or gummy deposit on the turbine blades, thus lengthening the time between inspection and overhauls. Based on actual experience with native labour in Tunisia the turbine section of a free piston installation need not be inspected under 25,000 hours running and no maintenance has been found necessary in this period.

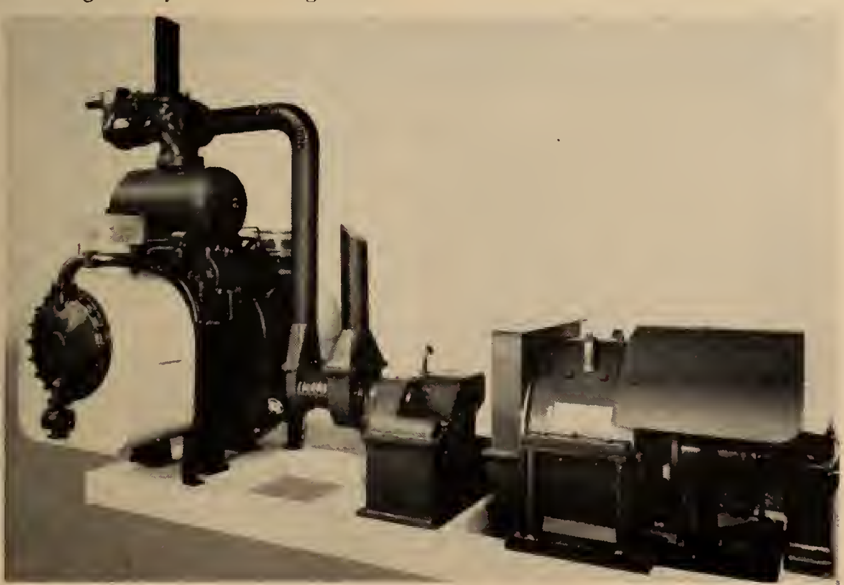
The moving parts are fewer and lighter than in corresponding diesel installations and there are no crankshafts or cam operated valves, load carrying bearings etc., and fewer and simpler pistons and rings.

Maximum maintenance weight to be handled on a GS.34 gasifier is only 550 lbs. for withdrawal of the piston assembly.

No additional head-room is required to facilitate dismantling and 3 ft. 6 ins. clear space at each end is sufficient to permit the drawing of the pistons etc. No valve grinding or fitting is necessary with free piston arrangement, and there are no tappets to adjust.

Complete stripping and rebuilding of a gasifier can be done by six men in one day, and ordinary service by two men in five hours. By providing standby gasifiers all maintenance and inspection work can be carried out in day shifts thus dispensing with night work.

Fig. 6. 200 Kw.D.C. Marine auxiliary generator driven by a high speed turbine and energized by a CS. 75 gasifier.



Liner wear is more evenly spaced over both the circumference and length of the wall than is the case with a conventional engine and no characteristic ridge is formed above the limit of travel of the top ring; neither is there the same tendency for bores to wear oval, there being an absence of the side thrust which is imposed by the angularity of the connecting rod in a conventional machine. The effect of heat transfer is also spread over a larger area of the liner wall due to the greater rate of the acceleration of a free piston compared with one confined by mechanical linkage. As has been shown, due to the absence of stored energy, the free piston engine is inherently non-destructive and offers advantages in unattended installations or where supervision is limited.

Rating

The rating of the free piston engine can be separated into the rating of the gasifier itself and of the complete gasifier-turbine set.

The gasifier rating is primarily a matter of the maximum loading of the diesel pistons for good endurance, the limit set on the piston stroke in relation to the outer mechanical limit of its travel, and the maximum permissable engine-case temperature.

The present continuous rating of the GS.34 is 1250 GHP but outputs of well over 1500 GHP have been sustained for considerable periods on test, so that the CMR may be considered to be conservative.

Two conditions can be considered for the derating of complete gasifiers/turbine sets viz:—

(a) with an "adjusted" turbine, the nozzle area of which is designed to suit site conditions.

(b) with a "fixed" turbine, the nozzle area of which is designed for other than site conditions of ambient and altitude.

The derating for an "adjusted" turbine is only about one-fifth for temperature and one-half for barometer, as compared with the derating for a conventional diesel engine.

Applications

Applications have covered a wide range and considerable experience has now been obtained in continuous operation both in central electricity stations and with Marine propulsion units.

Over 300,000 GHP of gasifiers are either in operation or in course of production, and an impressive number of operating hours have been accumulated.

Electrical Applications

Of the existing electrical applications, a 1200 k.w. installation has been running at Rheims since December 1951. A similar installation at Metlaoui, in Tunisia, has been running since 1953, operating 24 hours a day, burning residual fuel, and has now run something over 25,000 hours. The turbine was first inspected after 12,000 hours, and the blades and bearings were found to be in excellent condition,—and the very light deposit on the blades was found to be easily removed and confirms that no corrosion or deposition troubles should be experienced even when running on cheap fuels.

A 600 k.w. set was installed at the Cerveceria Modelo, Cuba, in 1953.

A 6000 k.w. installation was made at Cherbourg for the Electricity de France in 1955, and a similar installation at Tours.

A 3000 k.w. installation was made at Ajaccio, Corsica, in 1955.

During 1956 two 1500 k.w. sets were installed in Noumea and a further 1500 k.w. set for Companie des Phosphates de Gafca, at Redeyef, Tunisia. A 1500 k.w. set was installed in Lome (Senegal) two 3600 k.w. sets at Augusta, Corsica, and two 1500 k.w. sets for a cement Company at Chekka, Syria, a 4000 k.w. set for Egypt, and a further set for Pointe-Noire, Cameroons.

In addition the following sets are known to be on order and in course of manufacture.

2—4000 k.w. sets for Sicily.
1—1500 k.w. set for England.
6—6000 k.w. sets for Singapore.
2—3000 k.w. sets for Malaya.
2—6000 k.w. sets for Finland.
2—3,000 k.w. sets for Malaya.

It will be noted that many of these installations have been operating in remote parts of the world where they are maintained by native labour, and operating experience has been so satisfactory that in many cases repeat orders have been received, which would confirm that maintenance is low and well within the capacity of comparatively unskilled personnel.

The foregoing covers generating sets in regular commercial operation, and in addition, a number of sets have been supplied for experimental purposes.

Marine Applications

The largest number of marine installations are under the French flag, where the French Navy adopted a free piston gasifier turbine installation as standard for a class of fast minesweeper, which was first laid down in 1953 and now consists of 21 ships. The free piston propulsion system being free of vibration does not transmit any significant signal through a ship's hull plating to the sea which makes it particularly suitable for this application.

The 1100 ton coasters *Cantenac* and *Merignac*, in regular service since 1953 and 1954 respectively, have been in continuous operation and have achieved the best record for regularity of their fleet, with phenomenally low maintenance. It is particularly noteworthy that these ships are popular with both the deck officers, due to ease of manoeuvering and reliability, and with the engine room staff, due to ease of maintenance and acceptable engine-room conditions—to the extent that transfer is resisted to other ships in the fleet with conventional engine-rooms.

A 6000 SHP installation has been made in the converted liberty ship *William Patterson* by General Motors. This ship is in regular ocean service and has completed several transatlantic crossings. The weight of the propelling machinery and auxiliaries is 385.4 tons as against 463.8 for the original machinery of only 2500 SHP. Auxiliaries account for nearly 140 tons. Average speed on trials was 16.7 knots with six gasifiers, 15.4 with five and 12.3 with four operating. Final operating costs for this ship have not yet been made available but corrected fuel consumption for all services is understood to better .510 lbs/shp/hr as against .494 lbs/shp/hr for the sister ship with geared diesels. The Patterson uses commercially available bunker "C" and no special processing is required other than centrifuging.

The 1,350 ton 15 knot deep sea trawler *Sagitta* has now been 270 days at sea since being commissioned in January 1958. She is equipped with two GS.34 gasifiers feeding a 2000 SHP 8000 RPM unidirectional turbine driving a C.P. propeller through reduction gears. Fuel Consumption has averaged 7.2 tons per day using heavy oil. Two sister ships have since been ordered.

The *T. V. Morar* of 9,200 ton deadweight capacity and 2,500 SHP has been in regular service since the beginning of the year and has attracted much favourable comment from ship owners and others who have sailed in her.

The *T. V. Morar* is the first British vessel built specifically for free piston propulsion and her engine room is the first all British built marine installation of this type. The installation consists of three GS.34 gasifiers feeding a reversing turbine running at 5250 RPM and driving through reduction gears to a propeller at 115 RPM.

The ship is an ore carrier and is built to the maximum dimensions considered to be suitable for a vessel calling regularly at Port Talbot. The weight of the whole machinery is only 410 tons as against a total of 630 tons for the diesel sister ship which gives an increase in deadweight of about 200 tons. The use of free piston machinery could have permitted a reduction in engine-room length of ten frame spaces, but the vessel being an ore carrier, it was found to be unnecessary to make use of more than five. These five frame spaces give an increase in bale capacity of 12,411 cu. ft. over the sister ship and also allow an increase on 309 tons in water ballast capacity.

The *T. V. Morar* has a designed service speed of 11 knots. The fuel consumption of the MK 11 turbine intended for this vessel is 0.42 lbs. per SHP/hr using heavy fuel of 1,500 seconds viscosity. On trials, speeds of 12½ knots were achieved on three gasifiers and 9½ knots on two gasifiers with the third shut down.

Under construction are installations for a cargo ship of 2000 SHP for France, Fenwick & Co. Ltd., 4000 SHP for a dry cargo vessel building for Bolton Steamship Co. Ltd., a 4000 SHP installation for a cargo liner for British India Steamship Co. Ltd., and a 7000 SHP propulsion set for a new cargo liner building for Crest Shipping Co. Ltd.

Two 16,000 SHP installations are under construction for French vessels and seven 4000 SHP installations are being built for USSR and a 3,000 SHP installation is being built for a Whale Catcher in Holland.

In addition to these, a number of marine auxiliaries of 200 k.w. incorporating CS.75 gasifiers are being installed in ships in England.

Industrial Applications

In addition to the above applications, gasifier turbine installations have shown themselves to be suitable for other duties such as pumping water and compressing gas, and a pumping installation has been in operation in a Paris waterworks since 1955.

A free piston turbo compressor is particularly suitable for heat pump applications as the turbine can be designed for direct coupling at the most efficient compressor speed and all the heat can be recovered.

As a result of a survey of the most suitable power source, free piston gasifiers were selected for the 13,000 SHP gas compression plant in the new I.C.I. Synthetics Plant at Wilton, England. This installation consists of 13 GS.34 gasifiers feeding into a common ring supplying 6 turbo-compressors. A GS.34 Turbo-compressor is to be installed in Australia.

Rail Traction

The ability to burn cheap, residual fuels, coupled with the favourable torque characteristics of the turbine makes the gasifier turbine power unit very suitable for traction applications.

A 1000 HP locomotive incorporating a single GS.34 gasifier was built by Renault and has been in regular mainline service since 1952. The gasifier and turbine of this locomotive are carried on the main frame and the drive is transmitted to the axles by means of a gearbox and carden shafts. This particular locomotive has been burning a light furnace oil with a viscosity of 85 seconds Redwood at 100°F. and shows an appreciable economy against a diesel locomotive running on gas oil; this is accentuated by the fact that gas oil is taxed in France, as in some Canadian provinces, whereas furnace oil is not.

This locomotive has run well over 125,000 miles in normal operation and the experience gained has been used to design free piston gasifier locomotives of 2000 HP which are also built by Renault. A 2000 HP locomotive is also under development by General Motors in the United States and 3,000 BHP locomotives are being built in U.S.S.R. as a result of satisfactory operating experience with Free Piston Gasifiers.

It would appear that the low temperature and pressure to which the connecting ducting between the gasifier and turbine is subjected would lend itself to the design of a locomotive in which small, high speed turbines were mounted on the power trucks, where they could be directly connected to the axles through suitable gearing, as in a traction motor, the turbines being supplied fram gasifiers mounted on the main frame.

The CS.75 gasifier would appear to be particularly suitable for this application as their short length would enable them to be mounted transversely across the chassis and multiple units could be installed to deliver 3600 HP or more. Such an arrangement would facilitate maintenance by the replacement of individual gasifier units in rotation, with serviced units, and would greatly reduce the time during which the locomotive was out of service for maintenance purposes.

Automotive Applications

The gasifier turbine is also suitable for automotive applications, and at least four companies have small units in the range 100 HP to 250 HP under development which would be suitable for powering commercial vehicles and possibly private automobiles.

The low temperature gas turbine has special advantages in multiwheel drives where differentials can be dispensed with and for the steering of tracked vehicles. The turbine performs a similar function to a torque converter and for most applications variable speed transmissions can be dispensed with, and the turbines can also be designed to give up to 60% reverse torque which may also be used for braking purposes.

General

Applications to date have followed conventional lines, but the characteristics of the gasifier turbine unit lend themselves to applications where mechanical power is required to be taken from shafts at relatively high rotational speeds.

Turbine speeds can be matched to those of highly efficient rotary compressors for the delivery of process gas etc. An interesting application is the driving of a compressor associated with a heat pump which would also enable the heat content of the exhaust gas to be recovered. Other applications are the driving of high frequency generators in association with electronic apparatus, high frequency electric furnaces etc.

The quick starting feature offers interesting possibilities of designing large no-break mains failure standby sets of a type where the turbine rotor would substitute for the no-break flywheel.

In addition to straight gasifier turbine applications, there are attractive possibilities to be had from mixed cycle installations in which gasifiers are associated with steam installations.

The exhaust discharged from the gasifier-turbine contains approximately 80% of unburned air, which can be used under a boiler as preheated furnace air. This has the effect of raising the overall steam plant efficiency and the combined efficiency of a gasifier and steam plant can approach 33%. Such a combined cycle is of particular interest in Marine installations, as it enables a reduction to be made in boiler size, and enables the earning capacity of a vessel to be increased.

Conclusions

The free piston engine combines the advantages of the high thermal efficiency of the diesel engine with the torque characteristics of the gas turbine; it also eliminates most of the disadvantages associated with these types of prime mover.

The free piston engine is now out of the development stage and is firmly established, particularly in the fields of industrial power generation and marine propulsion, and its applications in these fields are expanding rapidly, particularly in the unit range from 1000 to 16,000 H.P.

The application of the free piston engine to road and rail traction is not yet out of the development stage, but the operating characteristics of this engine are such that it must become firmly established in this field also.

The free piston engine has numerous advantages over other prime movers for certain applications, and these include reliability and ease of maintenance with relatively unskilled labour, the elimination of vibration and resulting saving in foundations and structural supporting members, as for instance in ships, light unit weight and bulk, which lends itself to trans-shipment by air, and maintenance without heavy lifting tackle. The ability to burn a very wide range of fuels which includes residual oil, the ability to deliver a stalled torque, and the ability to deliver power at high rotational speeds suited for direct coupling to turbo-compressors, high frequency electrical generating apparatus etc.

Further improvements may be anticipated in specific output, the fuel consumption at light loads, and on widening the range of applications, particularly by the development of small lightweight gasifiers suitable for automotive applications.

The author acknowledges the use of information made available by Société Industrielle Général et Mécanique Appliquée, Alan Muntz and Co. Ltd., The Free Piston Engine Company Limited, and the many earlier publications which have made this paper possible.

DESIGN OF A FUNCTIONAL STRUCTURE IN OR ON ROCK

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No man is an Iland, intire of Itselfe
John Donne; circa 1625

THE SCIENCE and art of engineering has been divided and subdivided continuously since sappers first moved from military engineering into civilian service. The specialist in each branch finally discovers that his problems are not unique, but constitute the problems of engineers in other branches, so now a coalescence of engineering knowledge for the design and construction of the major projects is necessary. Civilization has reached a stage where it appears that men may again have to go underground and live as cavemen. The design and construction of underground excavations for the housing of power plants, warehousing, factories, bomb-proof record storage, and the accommodation of people as a civil defence project falls in the field of the civil engineer.

This paper is intended to point out the interdependence of civil engineers, geological engineers, and mining engineers in the design of these underground structures. The mining engineer, if he has any unique qualifications, is learned in the construction and support of underground excavations. He is inclined to take a pessimistic view of ground support surrounding underground excavations because he is seldom asked to work except in rocks that have been subjected to the tremendous geological disturbances which have brought about most orebodies.

The mining engineer is accustomed to working with stresses beyond those employed by most engineers and if he has learned nothing else he does know that there is no such material as "solid rock." There is a parallelism between structural members used by other engineers, and their counterparts used in structures underground. The mining engineer however develops his structures within a stressed mass. The behaviour of rock as a structural material is examined, in this paper, in relation to the stresses to which it is subjected in the peripheries of underground workings. The intention is to demonstrate the unique knowledge which is stock-in-trade for the mining engineer and its usefulness to reveal and either utilize or neutralize factors that affect the design of underground excavations. Foundations, open excavations, and closed excavations are considered.

Structural Elements in Excavations

The most obvious structural member in an excavation is the beam or arch overhead. The next feature observed would be the side walls, which may be considered as analogous to either pillars or abutments. The design problem at once apparent is that there is only one free face to the arch or to the abutment. The thickness is not revealed by observation. The other elements entering into underground structures are struts, or an assembly of contiguous struts that may be considered to form plates or slabs. These are usually measurable in dimensions because usually they are of different material from the primary material in which the excavation is being made. A dyke is an example of this structural element.

Physical Characteristics of Rock

There can be no intelligent design unless the physical characteristics of the materials entering the design are known. Rock is made up of mineral crystals or amorphous material, which may be crypto-crystalline. It is a material similar to concrete in that there are particles having varied physical constants in a matrix of other materials also having varied physical constants. The standard tests that have been devised for other construction materials are parelleled for the testing of rock specimens. The U.S.B.M. (United States Bureau of Mines) has designed and published a series of standard tests for rock specimens.[1] These are bulk tests. The data obtained refer to the average behaviour of the assemblage of minerals in the test piece which represents the rock under test. The tests are designed to be made on drill core which is the easiest and the most common way to get samples of the rock which will be involved in the construction. The orientation which the drill core had in the parent rock is important, though not included in the above reference.

Standard Tests. A length of drill core showing no visible defects is examined sonically to determine the velocity of sound, longitudinally and transversely, in the diamond drill core. The sonic measurements, and the density of the rock give a value for Young's modulus, shear modulus or modulus of rigidity, the damping capacity, and the derived function, Poisson's ratio. These characteristics are determined under conditions of no applied stress. Density is an important factor in these determinations and it will change with changes in the bulk modulus. The values obtained by sonic tests, apply only to the conditions of no stress and will be different for different degrees of stressing. They only serve to compare the characteristics in the unstressed state.

The strength in compression is measured by preparing a suitable cylinder of rock from a piece of diamond drill core and compressing it to failure. Auxiliary measurements at this time may include the use of strain gauges to find the axial and the lateral strains to give new measurements for the moduli and Poisson's ratio. The strength in tension is difficult to learn because apparatus to test the strength in tension is difficult to devise. A measure of the strength in shear is made by a transverse fracture test which determines the modulus of rupture, a characteristic having a value somewhere between the strength in shear and the strength in tension. The U.S.B.M.[1] specifies other tests having to do with hardness and abrasion resistance, but these do not appear to have any connection with support of underground excavations.

Time Effect. Laboratory studies not prescribed by the U.S.B.M.[1] have been made of stress-strain-time relationships. This introduces the phenomenon of creep and plastic deformation. Most rocks when compressed rapidly and released from pressure

Fig. 1. Photoelastic studies showing the stress fields around openings.

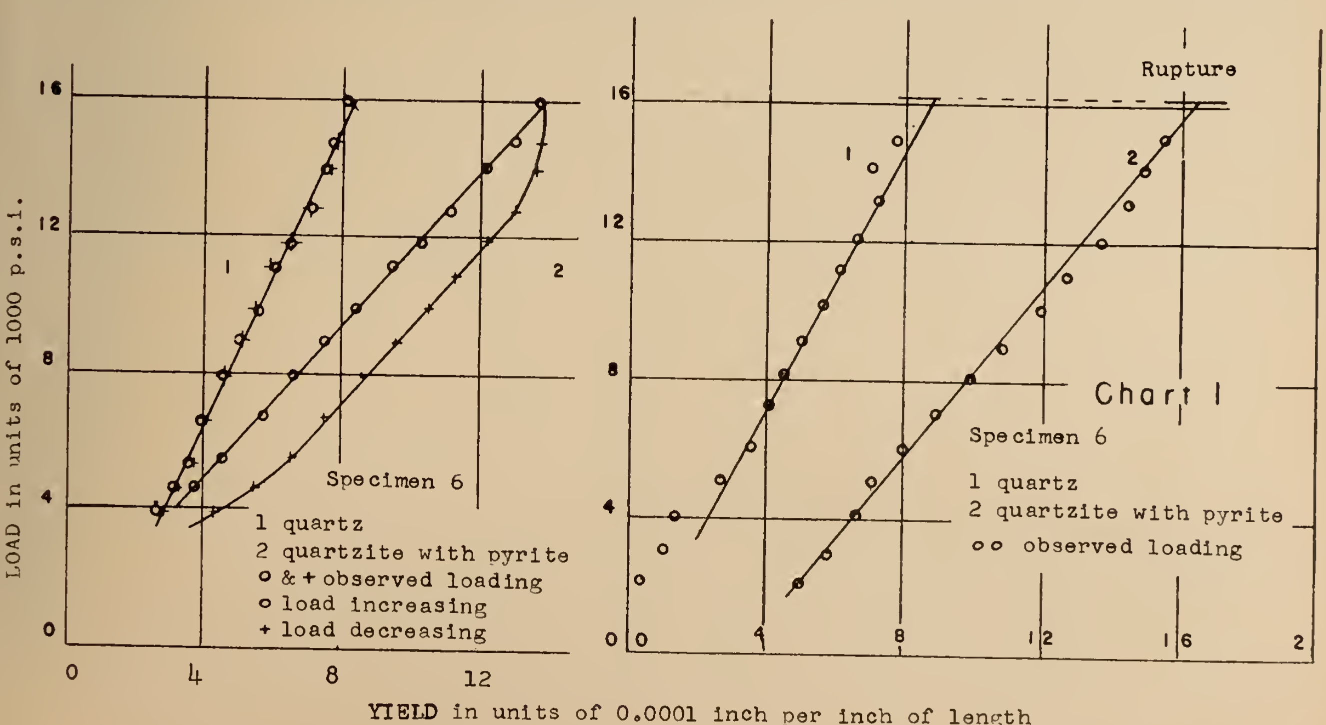
rapidly show a straight line stress-strain relationship and the strain is recovered. If the stress is applied slowly or is maintained at any level on most rocks there will be increased strain. If the stress is released quickly at the end of an elapsed time the stress-strain relationship will be nearly linear and nearly parallel to the line showing the rapid application of stress. Much of the residual strain remaining at the conclusion of the unloading cycle will be recovered at a rate decreasing with time. Whether all strain will be recovered with sufficient time or not depends on the behaviour of the rock minerals when stressed.

Behaviour When Stressed. It has already been stated that rocks are made up of an assemblage of minerals with varying physical characteristics. When the rock is stressed some minerals behave as elastic (Hooke solid) bodies, and others as plastic bodies (St. Venant solid), and others as viscous (Newtonian liquid) bodies. When the stress is first applied the elastic bodies behave elastically, and plastic bodies behave elastically up to the point where they, the plastic bodies, yield plastically, and the viscous portions behave elastically for a small amount of strain then proceed to flow to accommodate the pressure.

When the specimen is destressed the elastic particles are restrained from immediate recovery of strain by the surrounding viscous matrix and the plastically deformed particles remain plastically deformed. Stress bringing about a reversal of the viscous flow and arising from the elastic qualities of the Hooke's bodies is resisted by the viscous matrix but it yields and there is a slow recovery of the strain in the elastic bodies with the consequent readjustment of the viscous matrix. Eventually all the elastic strain will be recovered but the plastic deformation will not be recovered. These phenomena are shown in Charts 1 and 2.

Stresses Around Openings

The distribution of stresses around openings must be known to permit proper design to accommodate them.



These stresses around several standard shaped openings have been studied by many mathematicians and physicists in a manner referred to here as the classical treatment.

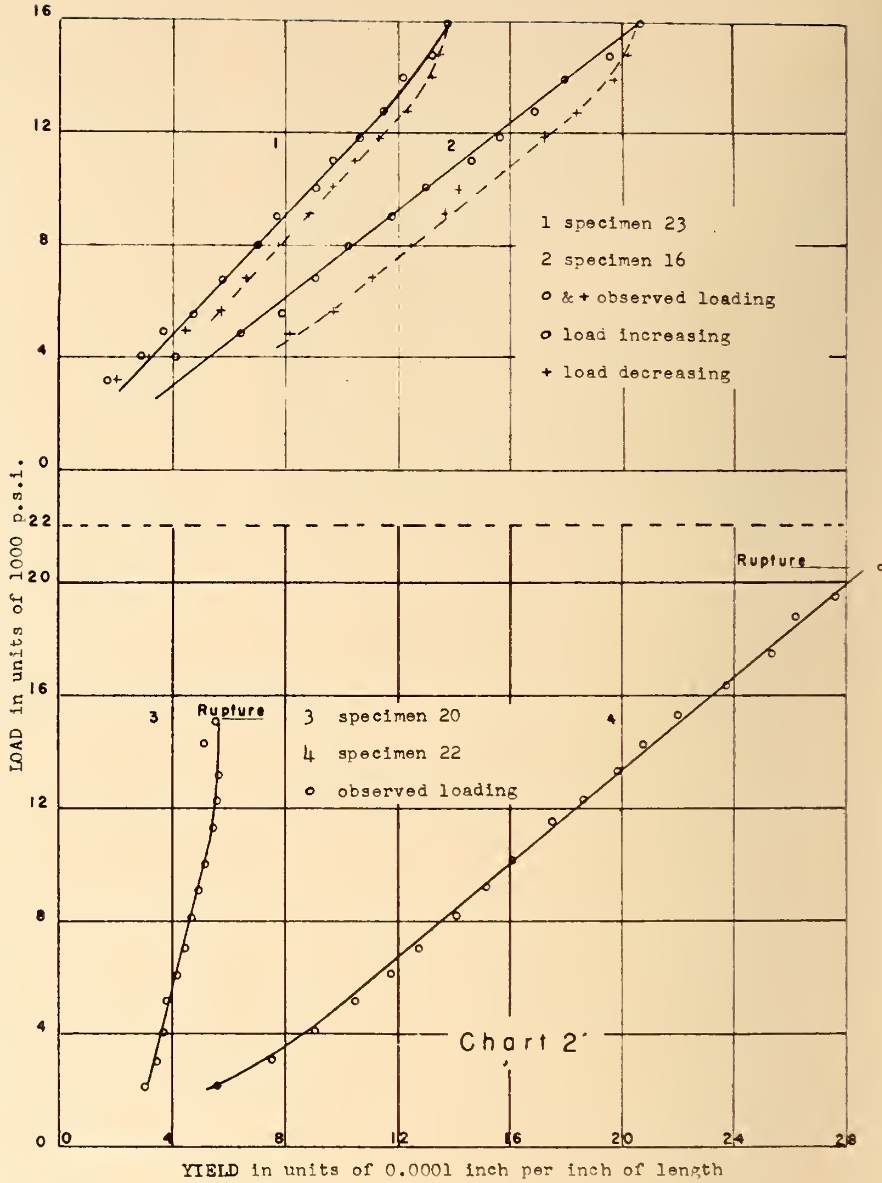
Classical Treatment. The first shape examined is the circle. Most books on mechanics of materials or behaviour of materials under stress, or theory of elasticity derive formulae to show the stress condition around openings of various shapes. Under conditions of unilateral compression the circle will display a tensile, tangential stress equal to the applied field at the diameter marked in the direction of the field of stress and at the diameter normal to the field of stress there will be a compressive, tangential stress of three times the applied field. The isotropic stresses are calculated by adding the effects of a unilateral field acting at right angles to the first field. The result is a uniform tangential compressive stress around the circumference and equal to twice the applied field.

Similar calculations are made for other shapes and the results of such calculations are shown in Chart 3, which is from R. I. 4192; Duvall.[2]

The mathematical treatment is supplemented by photo-elastic studies to show the stress fields around openings to confirm the mathematical findings and to examine fields about openings too irregular for reasonable mathematical analysis. The photo-elastic findings check the mathematical findings and the stress fields about different openings are shown in Fig. 1.

Pragmatic Treatment. The classical treatment describes the stress distribution around an opening in material that is isotropic. Rocks are aeolotropic, and controlled stress fields are not available. There are two types of stress to be considered in the field of an excavation in rock, and a third type which is a combination of the two. The first is superincumbent weight, and the second is orogenic stress.

Superincumbent Weight. The rock in which an excavation is to be made will be stressed and strained to a degree permitted by the Young's modulus and Poisson's ratio of the rock involved. An element of the rock at depth would be in a condition analogous to an apparatus consisting of a cube having movable diaphragms as boundaries and equipped with tensed springs pressing outward against each of the cube faces (diaphragms). The degree of strain in the springs would be a function of the weight carried above the elemental



cube. Dash pots, to prevent instantaneous release of strain, must be added to the system. When the balance attained by the system in the elemental cube is disturbed by an excavation all the strain due to the superincumbent weight acts as if it were concentrated in the elemental cube, and is a function of that weight. The elastic strain in the springs will be recovered as rapidly as will be permitted by the restraint of the dash pots which serve to simulate the viscous flow action of the matrix of the elastic particles of rock. There will be a release of upward stress and the superincumbent prism of overlying rock would seem to have no support. Support will be provided by contact between the walls of the prism and the surrounding rock in a manner analogous to the behaviour of granular material in a deep bin where the floor of the bin only has to support a small arc of the granular material. The rest of the weight is carried by the wall of the bin as may be seen by Jansen's formula, sometimes called Ketchum's formula.

The vertical pressure V in a deep bin is

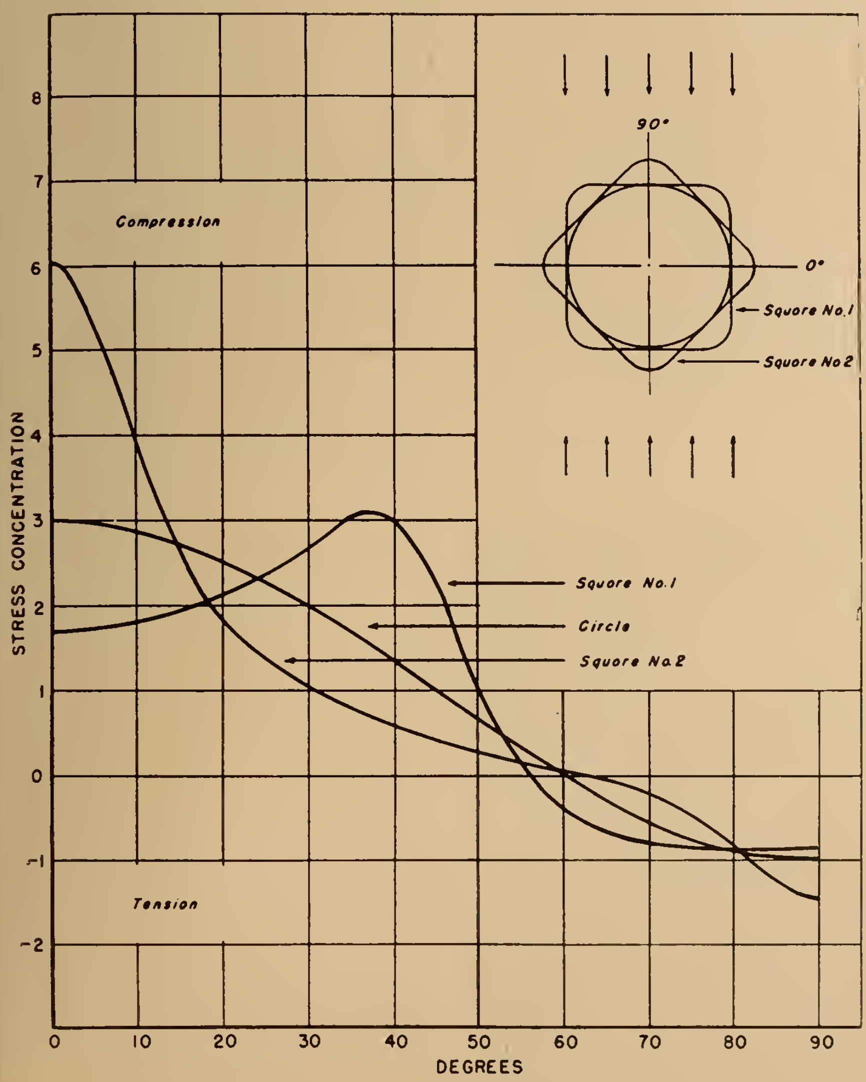
$$V = \frac{WR}{K\mu}\left\{1 - \epsilon^{-K\mu' h/R}\right\}$$

where h represents any height at which V is determined. It is the only variable and $\epsilon^{-K\mu' h/R}$ is a decaying function that rapidly approaches zero with increases in h, and V becomes constant with respect to h.

It is established that the roof (back) of an excavation will only be deformed in good time by the recovery of the elastic strain which was brought about by the superincumbent weight. Once the deformation has accommodated this elasticity the distance to the surface has no effect. The support will be supplied as a beam, but because rock is always weak in tension and usually has actual or potential discontinuities, the support is provided by an arch described by Evans[3], as the voussoir beam. The abutments, at the ends of the beam, will be stressed to accommodate the weight of the intradosal material and the horizontal stress that is already there, from Poisson's ratio for the rock, in the undisturbed ground. This stress will be in a direction controlled by the magnitude of these two components, and applied at the corners of the opening. The walls of the excavation may be considered to extend as the walls of the prism to the surface and, as pointed out above, will carry the superincumbent load. Consequently at the corners of the excavation the ordinary field of stress is increased by having to carry the stress from over the opening and the horizontal stress formerly in the rock. The application of stresses of different magnitudes and directions will either produce a failure in shear at the corners or be accommodated by an adjustment at the corners of the excavation to bring the various stresses in balance. The wall of the excavation will be acting as a plate with a body weight equal to the normal vertical stress field and an imposed load equal to the load over the excavation. These features have been analysed by Emery.[4] A similar reaction will take place in the floor section of the excavation.

Fig. 2. Successful application of rock bolts.

Chart 3



Orogenic Stresses. Probably no rocks with a geological history in the earth's crust have remained undisturbed since they were established. They have been subjected to warping and folding and to carrying great weights of superimposed rock. Some authorities estimate that as much as 24 miles of rock have been worn off parts of the Precambrian Shield in Canada. The phenomenon that gives the best appreciation of the extent of the stresses involved in crustal deformation is probably the reverse fault where the pressure being relieved by lateral thrust has been sufficient to shear the formations and slide one side of the shear over the other with a consequent lifting of all the rock above the member. Prior to the rupture by a thrust fault a horizontal segment of the earth's crust must be considered as a plate in a high state of stress, and an excavation in this plate will permit a rapid release of some of the elastic strain and some with a slower rate that will decrease with time. This stress may often be greater than the stress applied by the superincumbent load above the excavation. The process of accommodating the stress built into the rock will be the same as that of superincumbent stress.

Combined Stresses. A proper combination of superincumbent load stress and orogenic stress can result in a stronger structural member than either one would alone. Furthermore the resultant of the two stresses will always be greater than either principal stress. Morrison and Coates[5] examined the stress conditions in St. Venant solids and demonstrated that shear is resisted by the magnitude of the secondary stress involved in the shear. The beam over an opening may behave as the prestressed concrete beams used in construction do. The result would be firmer, stronger, wall boundaries for an excavation than if either one of the stress sources operated alone.

The physical characteristics that resist failure range from compression, the strongest, through shear which is intermediate, to tension which is the weakest. Rock is aeolotropic in its structure but in addition it is seldom continuous. It may be interrupted by bedding planes or by faults, which are obvious, or slips which are discontinuities in the rock. They may be microscopic in size or may not be developed, and the weakness would only be a place where a slip could occur under stress. These weaknesses may have any orientation, and intersecting planes. The result is that no rock design should assign any resistance in tension to a rock. It is usually safe to assign compressive strength and the most likely type of failure is in shear. Three types of failure may be recognized—fracture failure, plastic failure, and explosive failure.

Fracture Failure. This type of failure is most apt to be seen in rocks having high elastic moduli when they are compared to the compressive strength. It is not confined to the elastic bodies in the rock assembly. The viscous matrix components will fail in brittle fracture if the stress-strain rate is faster than can be accommodated by the rheology of the rock. The plastic failure is a failure in shear between small sub-divisions of the failing body. The result is a permanent set that is not recovered when the rock is destressed. The explosive failure is the release of stored up strain energy that occurs when stresses are concentrated in a part of the rock mass that is unable to accommodate them. The failure may be on a small scale, where brittle components of the rock fracture explosively to yield microseisims, or where the whole rock fails at once and produces rock bursts. There are several ways in which this energy may be concentrated in one portion of the rock mass. One manner that is easy to visualize is where a rock member with high moduli characteristics is under stress when surrounded by rocks with much lower moduli. The stress will be concentrated in the strong member which will carry it as a strut up to the point where violent failure takes place. This can work as well during destressing periods as during stressing periods. There will be a similar differential stress set up when the rock is being destressed and a crack may start. Recognition of the phenomenon of a crack tip being propagated through different types of rocks, fed by the strain energy of the rock so relieved, is recognized in the Third Theory of Comminution by Bond.[6] If the crack reaches the surface before it fades, spalling takes place.

One or all of these types of failure may be found in any type of working here considered, foundations, open excavations, and closed excavations.

Open Excavations. This term refers to openings in the surface which may be formed by stripping or digging.

Foundations. The most obvious cause of rock failure under foundations is the existence of either a weak clay, or shale, bed concealed below an apparently strong bed at surface. Under the weight of the foundation or under the different hydrodynamics induced by the existence of the structure the clay or shale or other weak bed will shrink or heave according to the controls available. This will result in an adjustment in the foundation and damage either by cracking or shifting in the structure. A second form of failure that may occur is due to warping of the bedded foundation rocks, or the presence of two types of rock formation with boundaries that are not parallel to the foundation plane. The two rocks will not have identical physical characteristics, and because of the varying thickness of one over the other there will be differential strains under identical pressures. These may be sufficient to cause cracks in the building. The stresses resulting from the application of a wall on a plane, in this case the surface of the rock, are examined in the Theory of Elasticity[7] and in other books on elasticity. A third, less obvious, source of failure is one that would result from the disturbance of the equilibrium existing on the upper side of a formation acting as a strut or plate in stress. The forces available in such a formation were exhibited in a marked way at the Marmoraton Mine, Marmora, Ontario, while the limestone was being stripped from over the orebody. At a depth well within the range of the height of many structures the differential pressure between the wall rocks and the pit bottom, where the superincumbent weight had been removed, permitted a condition of differential stress so that there were great upheavals in the floor of the pit. The pit was approximately 2400 feet by 1800 feet in area. "The area which was affected was a parabolic-like section at the north end of the pit having its focus on the centre line of the pit with the distance from the focus to the vertex being approximately 300 feet. There were two distinct upheavals which occurred approximately 300 feet apart. The apex of the upheaval reached an elevation of approximately 15 feet above the elevation of the pit floor."[8]

The conditions may have been aggravated by differential stresses set up as described above, when the elevation of the pit-bottom was approaching that of the underlying ore.

Fig. 3. An example of effective guniting at the McIntyre mine.

Failure in Open Excavations

The Marmoraton pit-floor failure is one type of failure. The most likely source of failure is in the walls of the excavation. Bedding planes, faults, and slips may have such an attitude that the walls will slide into the excavation. The other forces at work to bring about wall failure are those that every engineer has observed around an earth excavation. The phenomenon is extensively observed in soil mechanics. The difference between the behaviour of rock and soil is a function of the internal friction. If the rock, as a result of occurrences in its geological history, is minutely fractured or has incipient minute fractures it will behave as a soil. These fractures may result from man-made weakness. An example is the rock slide at Turtle Mountain, B.C.

Failure in Closed Excavations. The behaviour of rock in closed excavations is the usual field of investigation and control for the mining engineer. Rock is not an isotropic body and it is not subjected to isotropic stresses. If rock was isotropic, continuous, and subjected to isotropic stresses, no excavation would fail if the cover was thicker than the span of the opening. It has been pointed out previously that rock is aeolotropic and subjected to differential stresses. The elastic behaviour of rock makes it subject to failure in shear, and the shear planes will approximate 45° in direction to the applied force. The aeolotropic nature of the rock makes it improbable that this will be the only control. To a degree the failure, bit by bit, of the rock will result in a granular mass which is best analysed for failure in a manner analogous to the analysis used by engineers in soil mechanics. The rock is considered as fragments of elastic bodies subject to interface movement, which is restricted by the magnitude of the stress normal to the plane of incipient movement, and by the cohesion between the particles. This phase of rock mechanics is the subject of the paper by Morrison and Coates.[5] The evidences of failure by this agency are spalling, slabbing, and crushing.

Some rocks are sufficiently weak in shear to fail as plastic bodies and their failure is evidenced by a squeezing in of the walls surrounding an excavation. When this happens to an advanced degree the walls of the excavation will close the opening.

Support in Rock Structures

Rock may be supported in several ways. The first is to erect a framework against the walls and roof of the excavation to keep loosened rock from falling into the opening. The loosened rock takes up more space than rock in place so, at a reasonable height above the framework, support will be maintained against the unbroken back and an effective supporting arch maintained. Fracturing from elastic failure will be limited to a small amount of broken rock lying above the frame support.

Mining engineers have long recognized that the only satisfactory support for rock is rock, and the objective of another method of support is to make the rock self-sustaining by preventing the initial movement between rock components. The most recent practice in rock support involves the use of rock bolts which are anchored well behind the surface of the excavation and maintained in high tension. It is pointed out above that when a rock yields elastically the components are restrained from relative motion by the normal component of the pressure at the face of the potential slip. This is reinforced by the cohesion of the rock particles. The purpose of rock bolting is to increase this pressure normal to the slip planes that, if allowed to develop, would reach the surface of the excavation and result in a loosened rock. One phase of this manner of correction is analysed by Corlett.[9]

Fig. 4. Result of side pressure against a concrete lining in a small opening.

Another manner in which effective rock bolting improves the structural qualities of the walls in a rock excavation is by increasing the magnitude of the secondary stress which may prevent failure in the manner established by Morrison and Coates.[5] The failure between the adjacent rock particles is brought about by the ratio between the two principal stresses acting on the rock. If one of these, the stress in the direction of the rock bolt, is the lesser stress and it is increased by the bolt tension the ratio will be small enough to prevent failure. A third effect of the rock bolts is when the wall boundary of the excavation is in a condition of stability brought about by the proper balance of two directional stresses and it is behaving as a prestressed beam. The rock bolts will resist the tendency to destress by expansion into the opening and the prestressed condition will be maintained. It is clear that the maintenance of a high stress in rock bolts is needed to make them effective in any other manner than as a substitute for posts. Figure 2 shows a successful application of rock bolts. The structure in the foreground shows support by a framework.

The application of concrete as gunite is a third method used by mining engineers to preserve the walls of excavations. It is not widely used but has been used successfully under conditions that would make its successful application seem improbable. The gunite must be applied carefully on a thoroughly cleaned and scaled surface so it can form a bond with undisturbed rock. The result is that fractures are prevented from starting at the surface of the rock. An early description of extensive guniting was from the McIntyre Mine by Keeley[10] and that gunite is still operating effectively twenty-five years later (Fig. 3).

Plastic Failure. Plastic failure resulting in a rock that continues to yield permanently under pressure can, as pointed out above, completely fill an opening. When the plasticity is sufficiently developed it would seem that the only way the opening could be kept open would be to design a lining to resist isotropic pressures equal to the weight of the superincumbent rocks as one would design a pressure vessel to be submerged. Figure 4 shows the result of side pressure against a concrete lining in a small opening. The design of the lining resisted the vertical pressure more effectively than it did the side pressure. The method of placing the concrete made this probable.

Rocks that have plastic tendencies and fail plastically have been successfully held with gunite. Figure 5 is the picture of an excavation maintained in a yielding rock. The twisted columns have not moved relative to the gunited surface, which is undisturbed. The deformation of the columns was caused by the upheaval of the floor, which was not protected by gunite. A similar excavation in similar rock, made as a hoist room, held in an equally satisfactory fashion in the back, but the hoist was continually getting out of line because of the heaving in the floor. There may be, in addition to preventing initial movement in the rock, an added protection against the hydrodynamic action of water getting into the rock, or air getting into the rock, and causing the formation of new minerals requiring greater volume.

Policy or experience may dictate the use of massive concrete linings to maintain underground openings. Such linings must always be placed tightly against fresh undisturbed rock to be most effective. They have the disadvantage of requiring a larger excavation than would be needed for thin linings such as gunite, and the stress in the wall and roof members behaves as stress in such members behaves anywhere. It increases with the square of the span and in many underground designs one finds the span greatly increased, with the accompanying increase of stresses to be accommodated, and the strong rock which was taken out is replaced by concrete which is a much lesser structural material.

Explosive Failure. Explosive failure, referred to usually as rock bursts in metal mines or bumps in coal mines, often produces an amount of energy that cannot be resisted by artificial supports or by rock weakened by excavations. The only remedy available is to locate the excavation so it will not induce dangerous accumulations of strain energy in small bodies of rock. Great depth or wide openings are not needed to permit rock bursts. They have been known at shallow depths as a result of the inherent stresses built into the rocks during their geological history.

Fig. 5. Excavation maintained in a yielding rock.

CONCLUSIONS

Any excavation should be sited and designed only after a thorough examination of the proposed location by engineers and geologists. The field of the geologist would be a study of the lithology and geological history of the location area to determine the rock types and the extent of the tectonic forces involved. The geological study would involve surface examination and diamond drilling.

Diamond drill cores from the vicinity of a proposed excavation must be available to the designing engineer and proper teamwork between him and the geologist should provide some cores useful to both. Drill cores for the engineer must have definable orientations. He should determine the physical characteristics of the rocks, using the drill core as samples. He, if he has a proper background in rheology and structural engineering, can determine how the rocks will behave under the stresses imposed by the excavation. These factors will control the proper orientation, the permissable size, and the ground support needed, that will enter into the design.

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ABSTRACTS

OF 1959 ANNUAL GENERAL MEETING PAPERS

Precast Concrete as an Aid to Winter Construction
A. W. Smith and C. R. Crocker
Placing concrete in winter is difficult, may be extra costly and be delayed. Studies, since 1954, by N.R.C. Division of Building Research include feasibility of using precast concrete to meet Canadian conditions. Results are reported in the paper. Precast concrete is widely used in Europe, almost exclusively in Russia, for commercial, industrial, and residential building. Northern countries are of special interest, with climates similar to many parts of Canada. Technical literature search was supplemented by visits to precast concrete manufacturers, consulting engineers, architects, builders, laboratories, in U.K., U.S.A., and Canada. Future for precast concrete appears to be good, once accepted. One problem: difficulty of joining structural precast members at low temperatures.

Littoral Drift in Lake Ontario Harbours
R. J. Kennedy and A. Brebner
Depth in many Lake Ontario harbours is maintained by annual dredging. At Cobourg, Ont., annual cost is over $50,000. Problem may increase greatly with larger seaway traffic. Movement of material by wave action along the shore (littoral drift) is a world-wide problem, but fundamental knowledge is lacking and particular solutions may not apply elsewhere. Since early 1958 a N.R.C. Associate Committee, with members from Dept. of Public Works, N.R.C., and Queen's University, have studied the problem. The paper deals with the continuing collection of field data: wind and wave records, rate of change of underwater contours, characteristics of beach material and its point of origin. A parallel fundamental laboratory study is intended to relate wave characteristics to the transport capacity for any given material.

The Humber Sewage Treatment Plant
R. L. Clark
The Municipality of Metropolitan Toronto is carrying out the first complete pollutional control program of its kind in Canada. The Humber Sewage Treatment Plant, one of three major plants in the scheme, will provide complete activated-sludge treatment to all sewage flows from the Humber River watershed, ultimately serving 800,000 persons or one-third of the Metropolitan area. Initial capacity will be 50-million gal./day, from 475,000 population. Paper describes planning for flow, treatment, and plant site. Details include main plant design, components, facilities, power supply, structure, architecture, hydraulic design, staff facilities. Construction methods and progress are reviewed, and plant costs presented.

The Use of Fly Ash in Concrete by Ontario Hydro
I. Mustard and C. MacInnis
A resumé of Commission experience with the use of fly ash as partial cement replacement. Particular properties of fly ash, its effect on properties of concrete, and a summary of Commission applications (Niagara, St. Lawrence, Whitedog and Caribou power projects). Purchase specifications, method of handling the ash, effectiveness in producing desired results, and how fly ash concrete compares with regular concrete for job control, handling properties, etc.

Experimental Studies of the Effects of Blasting on Structures
A. T. Edwards and T. D. Northwood
Controlled blasting was done near six buildings to determine ability to withstand ground-vibration damage. Three buildings in wet silty clay soil; others in well-consolidated glacial till. Blasts increased until damage occurred, in attempt to correlate damage with size of blast and distance from structure. Measurements of displacements and accelerations of the ground, and at points in the structure, were also correlated with size of charge, distance, and soil type. In silty clay, difficult to produce horizontal vibration, but large vertical motion occurred; damage always associated with large settlement. In till, both horizontal and vertical components were produced; damage associated with ground wave rather than effects such as settlement. Results compared with damage criteria now in use. Suggest peak acceleration gives best correlation with damage.

Hydraulic Problems in Connection with the Development of the St. Lawrence River
H. W. Lea
Maximum St. Lawrence River flow is only double the minimum, due to Great Lakes storage. Any regime changes must avoid up- and down-stream damage. On approval of the navigation-power development in the International Rapids section, in 1952, the International Joint Commission established three boards; to report on regulation of Lake Ontario within 4-ft. level range; to approve plans and construction by Power Entities; to ensure, after completion of work, that Commission Orders about levels and flows are complied with. Detailed criteria are in the paper. Operations are covered from Montreal to Lake Erie, with information about the work and financing of the various Canadian and U.S. authorities concerned.

Backwater Computations for the St. Lawrence Power Project
H. M. McFarlane and C. C. Gotlieb
First part outlines the need for backwater computations between the power dam and Lake Ontario as basis of hydraulic design for the power project; describes available data and selection of parameters to cover all expected flow conditions. High-speed electronic computer used to investigate large number of cases. Preparation of computer data, interpolation of computations, and final arrangement of interpolated backwater slopes are explained. Second part sets up basic iteration for computing water-level difference between two ends of river channel; presents new method of using iteration to calculate water levels in a net of islands. Main features of computer program, method of computer runs, examples of input data, and computer results are described.

River Control in the International Rapids Section
K. A. Henry
Unusual circumstances arose in the International Rapids

Section during St. Lawrence Power Project construction, where many agencies and their contractors were engaged in works affecting river conditions. Paper outlines need for overall control of operations affecting river conditions, and administrative arrangements made to achieve this. Actual field control system, and need for continued use of models as construction and design tool, demonstrated by description of handling some of problems involved.

Design and Erection Features of the Vertical Lift Bridges for the St. Lawrence Seaway
W. G. H. Holt

Detailed record of design and erection features of vertical lift bridges for the Seaway. Canal, railway, and design engineers collaborated for best design after study of existing bridges in Canada and U.S.A., and of proposed sites. Complete description of superstructure, in three sections. Structural: arrangement of tracks and roads, design, characteristics of towers and spans, counterweight construction, means of access. Mechanical: design; counterweight ropes, sheaves, balance chains; machinery and operating ropes; operating torques and speeds; houses; auxiliary engines; accessories. Electrical: design; motors and control equipment; wiring; lighting; bridge operation. Other data: erection procedures; material quantities; canal, rail, road traffic.

St. Lawrence Power Project — Rehabilitation
J. H. Jackson

Problem: extent of headpond flooding from construction of Barnhart powerhouse and Long Sault Dam; human factors; communities established over 100 years. Analysis: studies for new locations of communities, roads, railways, etc.; professional assistance retained by Ontario Hydro; part of Town Councils and Planning Boards. Solution: actual construction program—field organization, roads and services, house moving, other buildings, shopping facilities, rental housing, shoreline improvements, railway and highway relocation. General review of program and its impact on area and communities involved.

Roughness Coefficients for Water Supply Tunnels
J. B. Bryce

Two concrete-lined tunnels (5½ miles long, 45 ft. finished dia.) convey water for Sir Adam Beck Niagara Generating Station No. 2 from intakes on Niagara River to canal leading to powerhouse forebay. Twelve piezometer openings in each tunnel to determine tunnel performance, roughness coefficients, head losses. Paper describes tunnels, provisions for field testing, test procedures, and results. Also comparison with design values.

A Method of Determining the Power Potential of Rivers with Many Reservoirs and Power Plants
G. S. Cavadias

Determination of the power potential of modern hydro-systems is a complex problem, and methods available for its solution are not entirely satisfactory. Paper presents method based on earlier work. (D. Johnstone, J. W. Hackney) and considers total power production of the system as basis for computations. Productions and installations of individual plants are considered as well as total system power potential. Paper gives theoretical basis for computations, and an example of the method applied to typical hydro-system.

Tests of Hydraulic Turbines – An Appraisal
J. J. Traill

Describes 100-year improvement in turbine efficiencies and part played by systematic testing. Value of tests to purchaser and in subsequent operation of power project. Describes and compares four methods of measuring flow of water through turbine, including thermodynamic method, now used in improved form in parts of Europe. Discussion of tests of turbine models and relation of test results to results expected in the prototype.

Photography and Electronics as Tools in Hydraulic Work
I. W. McCaig

General: lag in application to hydraulic measurements of recent developments in photographic and electronic techniques. Examples: photographic techniques—electronic flash. Bersimis-Lac Casse intake; photographic recording—shape of Lake Ste Anne transition; high speed cinephotography—Warsak cofferdam. Electronic techniques: stress in pressure measurements—Upper Campbell Lake development, Bersimis-Lac Casse turbines; stability measurement—Bersimis No. 2 surge tank.

Electrohydraulic Governors at Beechwood Generating Station
P. G. Fazzari and G. H. D. Ganong

Development of large power networks puts severe requirements on regulating equipment. New Brunswick Electric Power Commission chose new ASEA electrohydraulic type governor for Beechwood station. Conditions will vary with wide seasonal river-flow range. Station would carry base load in spring and fall; act as regulating plant in summer and winter. Governor should meet present requirements and future centralized load-frequency control. Paper describes Beechwood governors: operation, electrical and mechanical construction, operating and protective features; reports tests to determine best fixed characteristics for regulation and overspeed control. Frequency charts show possibilities of equipment under various operating conditions.

Design and Construction of Whitedog Falls and Caribou Falls
N. St. C. Haines

Hydro-electric generating stations at Whitedog Falls (Winnipeg R.) and Caribou Falls (English R.) were designed and built by Ontario Hydro staff, are remote-controlled. Described: site selection, turbine capacity, electrical equipment, auxiliary equipment, unwatering procedure; also construction of two powerhouses, two concrete dams, eight small earth structures, 34 miles of main supply road; clearing some 20,000 acres of land.

The First Cyclone Fired Boilers in Canada and Some Aspects of their Early Operation
E. K. Akin

Cyclone fired boilers installed at Water Street plant of Nova Scotia Light and Power Co. Limited. Planning, selection, installation of units. Reference to other services and equipment (fuel handling, ash removal); special high level oil burners to boost steam temperature for hot starting. Boilers can burn bunker C oil as well as coal; quick change-over. Early problems and their solution. Performance tests to be made after mid-1959.

Some Considerations in Steam Power Plant Design
A. G. Christie

Growth of integrated electrical systems requires new look at design of steam power plants. Rising fuel costs and load justify large steam units with highest possible steam temperature and pressure. Re-study needed of hydro sites with water storage to determine availability for peak load service with greater capability than for base load. High efficiency of steam plants to offset obsolescence and fuel costs may lead to such combinations as gas-turbine/steam-turbine joint operation at supercritical pressures. Pumped storage has limited future. Use of low grade fuels must be encouraged. Problem of sulphur and ash in fuels; economic uses being developed for powdered coal ash. Fully automatic plants reduce labour but need competent operators. Design of new plants must consider changing practice in plant details: steam generator construction, water treatment, superheat control, air heater operation, vacuum pumps, cooling towers, etc.

Special Features of the Brandon Generating Station
A. C. Blue, E. M. Scott, W. P. London, P. A. Pasquet

The Manitoba Hydro-Electric Board thermal generating station located at Brandon on economic considerations, notably cost of lignite fuel from southern Saskatchewan mines. Four units total 132,000 kw.; simpler feedwater heating cycle than usual as low load factor expected. All plant water softened before use. Circulating water system unusual for Canada; includes large cooling tower operating in adverse weather. Experience in burning lignite in tangentially-fired furnace. Panel arrangement in central control room as used in U.S.A.; not previously in Canada. Both hot water and steam used for plant heating and pre-heating combustion air. Electrical systems are described.

Economics of By-Product Power Generation
W. P. London and W. M. Newby
Steam turbines of back-pressure or extraction type are among methods of recovering heat remaining after primary conversion of heat into electrical energy. This heat may be used to obtain 'by-product' power, and so improve overall economy of power production. Equipment is considered in detail; factors affecting economy; conditions favouring such installations. Application of back-pressure and extraction turbines to different industries; effects of the differences in processes. Contrast: in pulp and paper industry, power demand exceeds amount available as by-product of steam demand; in petrochemical industry, reverse is often true. Cycles involving gas turbines; when these may be economically feasible; examples of application.

Graphite in the World Nuclear Power Program
late Sir Claude D. Gibb, K.B.E., F.R.S. Presented by H. B. Topham.
Reasons for use in Britain of graphite-moderated reactors for Calder Hall, current and proposed nuclear generating stations. Details of new reactor-quality graphite factory at Newburn Haugh, Northumberland; plant installed; construction problems. Raw materials, their control, processes to make the special form of synthetic graphite required. Plant can produce 10,000 tons/yr. nuclear graphite, 5,000 tons/yr. commercial material, e.g., steel-furnace electrodes. Total capacity can be expanded to 40,000 tons/yr. First load of reactor graphite accepted 16 months after start of plant construction. Capital cost some $16,000,000.

H.Q. Computation Centre for the H.E.P.C. of Ontario
(A series of four papers on various aspects of Ontario Hydro's program to centralize and integrate its data processing by a large scale digital computer and a teletype communication network. Data to be captured on punched paper tape, transmitted by teletype to data processing centre, where output reports printed on high-speed equipment and mailed to various offices.)
(1) *The design of the data communication system* (W. H. Sanders). Equipment provided by several firms. Only numeric input was bought; rest is leased. Operating and control procedures; correction of errors.
(2) *The network between regional offices and head office, and the tape sorting operation.* (S. J. Crossman). Outline of the system from regional offices to head office, and automatic message sorting at the latter. Details of network and equipment; procedure followed.
(3) *The circuit logic of the tape message sorter* (J. Rywak). Electronic circuitry used to achieve desired operation of tape message sorter, of which functions described in paper (2). Circuitry is assemblage of basic logic elements including shift register composed of bistable transistor switching circuits, diode gate circuits, and binary to decimal conversion matrices. Detailed design of basic elements not discussed.
(4) *Communications between area offices and regional offices* (H. R. Davis). Communications between 99 area offices and 9 regional offices of Ontario Hydro provided by Canadian National Telegraphs. Each regional office has C.N.T. Autoscan unit which automatically sequentially selects associated area offices; can be operated manually. Regional offices have modified page printers, with tape reperforators and transmitters. Area offices have transmitter distributor and transmitter control unit. Methods of interconnection of offices, including telegraph signals.

Edmonton Installs Canada's First Oil-Filled Pipe Cable System
C. Z. Monaghan and W. J. Pardy
Plans to increase Edmonton power system capacity to meet load growth. New underground 72-kv. distribution system, radiating from new city power plant. Two circuits now in use. Described: requirements; oil-filled pipe cable transmission system; service conditions; design of components; cathodic protection. Installation: material handling; training personnel; excavation, laying, welding; testing; cable pulling, splicing, terminating, vacuum treatment, oil filling. Special problems. Operating experience.

138-kv. Undersea Cable Across Georgia Strait
T. Ingledow
Power link between lower B.C. mainland and Vancouver Island includes five 138-kv. submarine power cables laid in 1956 between mainland and Galiano Island, another underwater crossing to Saltspring Islands, an aerial link to Vancouver Island. Submarine cable, largest yet laid, is gas-filled galvanized wire armoured type, made in continuous lengths, longest 14.7 miles. Selection of routes; difficult crossing conditions; method of loading and operation of laying ship. Practical results.

Magnetic Amplifier Control for Reversing Hot Mill Auxiliaries
R. L. Duke and L. R. Hulls
Electrical machinery and controls can now reverse hot rolling mills in less than two seconds. Time taken by auxiliary equipment to return metal to the mill after a pass is nonproductive; selection of equipment important to reduction of time lag. Drive motors and control selected after analysis of mechanical requirements and limitations of auxiliary equipment, which generally involves control of large number of d.c. machines. Drive must be easy to maintain, reliable, and simple. Magnetic amplifier used to excite generator of Ward Leonard drive suitable for control of auxiliaries: mill tables, side guides, screws. Response of these closed-loop systems must be adequate for purpose. Current limit protection required; detailed analysis required for proper design.

The Interconnected Power Systems of Nova Scotia and New Brunswick
G. D. Mader, T. F. Clahane
Major power utilities of Nova Scotia and New Brunswick will be interconnected in March 1960. Project discussed from inception to completion, and beyond. Individual utilities were limited to 50 Mw. generating units; 100 Mw. units can be accommodated on collective system; increased efficiency, lower unit capital costs. Individual utilities: service areas, rates of load growth, thermal/hydro ratio in service. Single sideband power line carrier system used for communications, telemetering, and relaying; operation of interconnection, how charges are applied, various types of interchange energy. Future developments.

Industrial Uses for an Auxiliary Low Frequency Supply
G. L. Tiley and E. Oldfield
Problems associated with control of a.c. motors, particularly variable-speed variable-load reversing drives. How a low frequency supply can solve some of these problems. Speed control: two types of mine hoist drives incorporating low frequency features. Other applications of low frequency: inching of large motors driving ball mills; similar machinery periodically operated at slow speeds; unusual application for hard anodizing requires single-phase low frequency supply. Common methods of producing low frequency supply; limitations.

The Development of an Electronic Detector of Flaws in Paper
M. P. MacMartin and N. L. Kusters
High quality paper must be flawless, dirt-free. Checked by visual inspection of single sheets. After investigation of characteristics, electronic flaw detector built; should be able to check paper at several hundred ft./min. without damage. Description of detector. Reflected light variations measured

by photomultipliers; optical scanning system; variations operate sorting mechanism. Present model checks paper up to 300 ft./min.; speed could be raised.

Shock Hazards of 60-Cycle Electric Currents
A. R. Morse
Review of experimental work on shock hazard of electrical currents and their physiological effects on heart, muscles, lungs, brain. Dependence of effects on intensity, duration, wave shape, frequency of current. Particular emphasis on 60-cycle frequency. Significance of electrical resistance of human body in conjunction with direct and indirect effects of applied voltage.

Processing of Low-Grade Iron Ore Using Petroleum and Natural Gas
P. E. Cavanagh
Iron ore processing, iron and steel production, historically based on coal fuel. New techniques allow use of oil or gas as heat source and reducing agent to convert oxides into metallic iron. Use of oil and natural gas in concentration of low-grade non-magnetic ores; also for production of metallic iron at mine site. Advantages of using techniques in Canada, particularly in West and at Lakehead.

Voluntary Standards — Vital to Progress
J. A. Reid
Economic progress of Canada largely dependent on use of voluntary standards; examples. Many standards evolved, only recently have organizations guided formation of standards. Several such organizations in Canada; industry and government; Canadian Electrical Manufacturers' Association. Future progress depends on ability of industry voluntarily to modify existing standards to take advantage of new products and processes; to create standards for existing and new products. Responsibility of producer and user industry management.

Engineering for Export
R. A. Frigon
Engineering exports in form of consulting engineering services, equipment, and construction contrasting play increased role in Canada's foreign trade. Engineering opportunities abroad, and benefits to Canadian firms; challenging problems; prospects under programs of international organizations and foreign governments for accelerated development; opportunities abroad for design studies, resources surveying, construction, equipment supply, management services; solutions to export problems; assistance available from Department of Trade and Commerce and Trade Commissioner Service abroad; financing; dealing with large scale projects, joint ventures. Approaches taken by competing countries. Actual cases of recent engineering exports from Canada show what can be done.

Geological Features and Foundation Treatment at the Beechwood Development
In the introduction, a brief outline of the general geology of New Brunswick and Maine with particular reference to the St. John River water shed is given. The surface geology including the effect of the last period of glaciation at the Beechwood site is developed. The investigational drilling and testing program, the reason for choosing the actual site and assessment of rock conditions based on this work is considered in some detail.
During the construction period the geological problems encountered are explained and the methods of overcoming these problems are given. Detailed data on the drilling and grouting program carried out in each section of the development is presented. This includes available information on the effectiveness of this program. Cost data for construction period, drilling, testing and grouting, etc. is stated.

A Gas Turbine Power Plant for Locomotives
Some of the gas turbine locomotive developments are reviewed in relation to operating experiences in various parts of the world.
In the light of this experience and of some of the characteristics of operation in Canada, certain lines of development seem in one or more respects to be attractive. In particular, it appears to be important to determine the practicability of relatively high power mechanical transmission and it is essential for most purposes to evolve a prime mover with better part-load economy than is normally attained by the simple low pressure gas turbine.
Both of these questions are examined and some experimental data are presented for comparison with design assumptions, and proposals are then made.

INSTRUMENTATION IN INDUSTRY

METAL FABRICATING

METAL FABRICATING plants in Canada comprise some twenty diversified industries manufacturing products from iron and steel, and non-ferrous metals. End products include transportation equipment such as motor vehicles, railway rolling stock, ships and bicycles. They also include structural steel, sheet metal products, wire goods, boilers and plate, castings pipe, hardware and tools, machinery, heating and cooking apparatus, aluminum, brass and white metal products and electrical equipment.

Together, the 3400 plants operated by these industries employ 360,000 persons, who add a value of $1,530 million annually by manufacture and have a combined output with gross value of over $5 billion. The ten year post-war period from 1946 to 1956 was one of steadily rising production, during which time hourly wages in manufacturing industries almost doubled, as did the prices of most of the materials used in manufacture.

By comparing the values added by manufacture per employee in 1946 for each industry group, with the value added per employee in 1955, and expressing the latter in constant 1946 dollars, it is observed that output per employee sharply increased for some industries during the ten year period while others showed little change and a few industry groups showed modest decreases in output per employee.

Best gains were recorded by motor vehicles, smelting and refining, copper and brass and white metal products, miscellaneous steel industries, sheet metal products and farm implements, in that order. Other industries which showed reduced values of output per employee included non-ferrous metal products, aluminum products, wire goods, shipbuilding, boilers and plate, and machine shops.

This paper appears to reflect improved methods in processing, handling and distribution brought about by mechanization in those industries showing gains in production per employee. But how much of it has been due to automation and instrumentation can only be conjectured.

Automation Survey in United States*

Highlights from a recent survey, and forecast of automation in the United States, published in "Automation", has strong implications for automation and instrumentation in Canadian industries as well. "One of the most compelling forces pushing industry toward increased use of more instrumentation and automation", it points out, "is the life-or-death need for the United States to stay out in front of the international race for scientific supremacy". This applies equally to Canadian industry.

Of 2,300 plants in 20 U.S. industry groups the percentage reporting they now use automation and advanced instrumentation varied from a maximum of 33 per cent in the petroleum industry and 28.4 per cent in electrical machinery, down to minimums of 6 per cent in lumber and wood, textiles and food products. Per cent using automation and instrumentation in metal fabricating was 10.3 per cent.

What they will buy in 1959

Out of 2,700 plants reporting, percentages planning to buy various types of automatic equipment, incorporating advanced instrumentation were as follows: drive and speed regulation, 41 per cent; interlocked control of operations, 33 per cent; automatic measuring and gauging, 25 per cent; automatic weighing; 16 per cent; process sensing and control, 24 per cent; tape and punch card control, 15 per cent; computer control 4.4 per cent; automatic data processing 12.2 per cent; and remote control, 6 per cent.

Other information of interest from the survey: 83 per cent of the development of machine and process control systems is done by the industries themselves with their own engineering staff, 24 per cent use the services of instrument manufacturers and 21 per cent employ engineering consultants.

Replies to Questionnaire

Replies from Canadian metalprocessing firms to a questionnaire recently sent out by the Journal, show that with few exceptions these firms purchase their electric power from utilities. Exceptions are very large producers or those who are also primary producers. In almost all cases consumption of power was reported checked, though in a few isolated cases the checking was done at the suppliers meters.

Half the plants replying had separate steam plants for heating and power. One establishment with several plants developed its own hydraulic power and produced its own steam requirements separately. Another large producer purchasing power had its own steam heating plant in a separate building for convenience. Generally the larger industries using large amounts of energy are those having separate steam plants.

Main Purposes of Instruments

Plants were asked what were the main purposes of their instrument installations. All of those replying answered it was to achieve better quality; almost as many stated it was to provide a continuous record. About half those answering also included as reasons economy in fuel consumption and regulation of pressure or flow. Few replies gave central supervision or reduction of labour forces as purposes.

As to what instruments were used for, replies indicated, in order of frequency, the following main purposes: to count or measure; to control automatic processes; to measure thickness of materials; to inspect material for flaws; to provide supervisory warning; to provide records for analysis; to measure other physical properties; to determine rate of flow; to measure composition of materials. In the larger establishments with diversified products and a high value for fixed assets, all or most of the above purposes were mentioned.

Some of the larger plants used special instruments in their metal-testing and X-ray laboratories. Other plants used them for automatic cycle control of machine tools and for diversified electronic tests of parameters, barometers, etc. or for carrying out altitude tests at hot and cold temperatures. In another plant instrumentation was principally used in connection with steel heat-treating and pump tests.

*Reproduced in part from an article in the Feb. '59 issue of "Automation" by special permission of the Penton Publishing Co.

A large industry with several plants, producing its own primary materials, uses instrumentation for measurement of its own materials; for measurement of large d.c. currents and voltages used in electrolytic production; and in measurement and control of melting and casting temperatures; heat-treating; plant safety and cost-accounting.

Who specifies, recommends and purchases instruments?

All replies to the question "Who determines instrument requirements?" indicated this responsibility rested with the company's own employees.

Several plants indicated suppliers or manufacturers of instruments were also consulted, while independent consultants or staffs of affiliated companies were rarely asked for advice. Where packaged equipment is purchased with its own instrumentation, the company engineers have little choice.

Specifications for instruments where needed are customarily drawn up by the companies' engineering staffs, though occasionally the plant or maintenance department or production department prepare them. The plant electrical engineer is often the one directly concerned. Sometimes the requirements are merely outlined and the instrument manufacturers make the detailed recommendations.

The choice of the supplier is made by the central purchasing department in most instances, though it is occasionally left to the engineering or plant maintenance department. Sometimes the engineering production and maintenance departments make a joint decision.

Servicing and Maintenance

Servicing of instruments is generally done by company staffs, sometimes assisted by suppliers' representatives trained in the instrument suppliers' plants. In smaller plants there are frequently service contracts with independents and occasionally service is purchased as required. One of the largest metal processing concerns with several plants across Canada does its own servicing in its largest plant with some 60 engineers and mechanics, while in its smallest plant servicing is done by one full-time mechanic.

There was no evidence from the replies that preventive maintenance programs are the general practice, and it appeared to be the exception rather than the rule. One of Canada's largest electrical manufacturing concerns with several plants reported such a program in its larger plants but not in the smaller ones. Two of the largest auto and truck manufacturers also reported having a preventive maintenance program.

It appears the general practice to carry a stock of spare parts or repair parts, and for the larger establishments with several plants complete replacement units are kept in stock. Choice of these spares and replacements is sometimes based on the instrument supplier's experience, but more often the stock of repairs is built up through the company's own experience.

Instruments incorporating optional plug-in features do not appear to be particularly suitable for most plants replying. One large manufacturer of electrical appliances with many plants finds them useful but did not indicate whether they were used in smaller plants or in the larger plants where it might be expected they would be most adaptable. One large auto manufacturer finds them suitable.

Instrument requirements generally follow standard commercial lines.

Instruments are purchased outright as a general rule. Only two companies replying to the questionnaire indicated instruments were occasionally rented when required: a large appliance manufacturer reported 95 per cent of his instruments were purchased and the remaining 5 per cent rented. A boiler and turbine manufacturer rents 20 per cent of his instruments.

Investment in Instruments

Plants were asked to state (a) their total investments in instrumentation, (b) their investments in instrumentation over the past five years, (c) their annual maintenance cost for instruments, and the value of their fixed assets. Several branch plants owned by U.S. companies withheld data on fixed assets, and this information could not be readily determined from local records.

Investment in instruments varied from a maximum of $100 500 thousand by a manufacturer of motor vehicles and $350,000 in the case of an electronic device manufacturer, to a minimum of $5,000 for a wire and wire products, perforated metal and screen manufacturer. Apart from new industries established since 1953, other plants reporting had made between a tenth and a half of their investment in instruments within the last five years.

Annual maintenance cost on instruments varied between $20,000 for a smelter and refinery, to $150 for a crane manufacturer with fixed assets of $3 million. One of Canada's largest makers of steel products ranging from structural steel to boilers and plate work spends $400 yearly to maintain instruments used for boilers and heat-control only, valued at some $25,000. Annual maintenance costs vary between one per cent and 10 per cent of the cost of the instruments, with the majority falling between 3 and 6 per cent.

Instrument cost related to fixed assets

Investment in instruments expressed as a per centage of total investment in fixed assets varied widely. For the large structural and plate work manufacturer who only used instruments for boilers and heat treatment; investment in instruments represented one hundredth of one per cent. A plant making construction equipment, with fixed assets of $4 million had spent 6 10 of one per cent of its fixed assets on instruments. An auto and truck manufacturer's investment in instruments was less than a third of one percent of fixed assets. Apart from these plants the investment in instruments appeared to vary between one-fifth and one-half of one per cent of total value of fixed assets.

Recovery time for Instrument Investments

Estimates of time required to recover the original cost of instruments varied widely, from less than one year for a company producing electronic devices to between 6 and 8 years for manufacturers of heavy construction equipment and makers of electrical and mechanical appliances.

The plant for producing electronic devices regulates air and temperature by standard non-centralized electromagnetic devices, and measures product parts with precision instruments. It also carries out diversified and complex electronic tests of instruments without which production would be impossible.

A company with several plants making heavy engineering products such as boilers, plate and tanks, cranes, and doing structural fabrication, estimated a five year write-off. This company, however, only uses instrumentation on boilers and heating equipment.

Plants estimating a write-off period of 3 to 5 years use instruments for controlling automatic processes and for providing supervisory warnings. These are plants producing construction equipment, power-transmission, material handling equipment and bearings, etc. Another group which estimate a 6 to 8 years period for write-off have instrumentation for

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INTERNATIONAL NEWS

FRANCE

FRENCH GOALS confidently expected to be achieved in 1959 are as follows:

STEEL—A record-breaking 15 million metric tons are to be produced.

GAS—The ten billion cubic feet natural gas reservoir at Lacq in the Pyrenees will be sending gas to Paris and Lyons for general use by November.

ELECTRICITY—Five new hydro-electric stations, including the big one at Vogelgrun on the Grand Canal of Alsace, will be put into service, and great progress will be made on the huge Roselend and Serre-Ponçon dams in the French Alps.

New production units will be added to almost all of the larger thermal power plants.

New centers will be built for the transformation of Lacq gas into electricity.

The fifteen locks of the Garonne river's lateral canal are to be equipped with an extraordinary installation for the production of electricity. Consisting of a series of small generators utilizing falls with no more than ten-foot water drops, they will furnish 20 million kw-h. a year. It is planned similarly to harness the Rance Estuary in Brittany.

The first large French nuclear center, "EDF 1", built primarily for the making of electricity, will be completed at Avoine, near Chinon in the Loire valley. It is to supply an annual 400 million kw-h. A sister center, "EDF-2," has now gone into construction nearby, and another nuclear electricity center, built within the framework of Euratom, will probably be constructed in the Ardennes region. (By 1971, atomic energy will account for 30 per cent of the country's total output of electric power.)

PETROLEUM—Oil production in Parentis (near Bordeaux), Gabon and the French Sahara is being increased, thereby reducing import needs from non-French sources.

The 375-mile pipeline joining the Hassi-Messaoud field in the Sahara to the Mediterranean port of Bougie in Algeria will be ready for use in October.

RAILROADS—The basic effort of S.N.C.F. (French National Railroads) will be to continue electrification of its lines. The equipment program for the electrification of the Paris-northeast triangle, serving the three principal economic regions of France, will be completed this year.

The French railroad network is expected to have a total of 4,375 miles of electrified lines by the end of the year, which will carry more than half its total traffic.

SHIPYARDS — French shipyards today are building the biggest tankers in Europe, and are designing and constructing ships (totaling some 500,000 deadweight tons in 1959) for French and foreign customers.

AIR TRANSPORT — In May, the "Caravelle" jet-liners will be put into commercial service.

PUBLIC WORKS — The large suspension bridge crossing the Seine at Tancarville near Le Havre, will be completed in July.

AGRICULTURE — The "phytotron," one of the most complete laboratories for agricultural research in the world, will be finished and ready for service at Gifsur-Yvette near Paris.

SPACE SCIENCE—At Nançay in the Cher Department. where a mile-long radiotelescope is already in service, construction of a second one is scheduled. These apparatuses permit "listening" to waves coming from outer space with an acuity never before obtained, it is said.

For the first time, French multistage rockets will be launched.

THE ATOM — Three new atomic piles will be added to the eight already in use, and construction will begin on three more. One of these will be a fast neutron pile cooled by liquid sodium, designed for the study of breeder reactors.

Most ambitious project will be the setting up of the Pierrelatte plant, in the Drôme region, where Uranium 235 will be separated from natural uranium. Its principal structure will cover 25 acres of the 1,500-acre site.

A plant for the extraction of Cesium 137 from atomic waste will be set up. (This product is of importance in industry and medicine, where it usefully replaces radioactive cobalt.) This is the first time recuperation of by-products from the combustion of uranium will have been accomplished in France on an industrial scale.

The center for the utilization of thermonuclear energy at Fontenay-aux-Roses will be greatly enlarged. Here, a new machine, called "Equator III," will be built.

France is constructing its first atomic submarine, and is perfecting its own A-bomb.

From *France Actuelle* March 15, 1959

SWEDEN

THE SWEDISH STATE POWER BOARD has during recent months celebrated its fiftieth anniversary. Later, five large power plants will be put into operation, two of which will be the biggest of their type ever completed in Sweden and even holding some world records, as to design and output.

Stenungsund, on the Swedish West Coast, will have a rock-encased steam-power station. Its initial capacity is 300 MW, but blasting out of two more rock halls is going on. With two more boilers and steam turbines, for which these rock enclosures are planned, the plant will produce 700 MW. The commissioning of the first stage of the installation is to take place on October 1.

Sweden's largest hydro-electric plant, Stornorrfors, which will have a capacity of 375 MW — 25 MW more than the Harspranget station above the Arctic circle — will be officially inaugurated on September 1 this year. The two first turbines have been running for some time, and a third is under installation. Two more water-power plants, Järkvissle and Langbjörn, having a capacty of 87 MW and 80 MW respectively, will start operating in the summer and autumn.

The fifth power station is the gas-turbine plant at Västervik, on the Swedish east coast. This plant will have a nominal rating of 40 MW and is to be taken into use commercially on October 1. It is of a new type for Sweden. The machinery was delivered by STAL.

At Stenungsund, each of the two machinery halls of the first stage, now completed, has the dimensions: 409 x 80 x 109 ft. Some 23,000,000 cu. ft. of rock have been blasted away, and more than half as much is still to be removed. The plant is to have double rotation turbines, said to be the world's largest, each consuming 34 tons of oil per hour. Its oil harbour can accommodate 60,000-ton tankers.

Stornorrforsen has three NOHAB turbines and ASEA generators. Their output is 125 MW each. They may be supplemented by a fourth unit later on. The tunnel area of 4,400 sq. ft. also constitutes a new record.

The most interesting feature of the Västervik plant, which is situated on an island, is that it will be automatically remote-controlled from the mainland. The two smaller hydro-electric plants feature interesting solutions of the dam-building problems, which have been tackled in entirely different ways. The former is a rockfill dam on a drainage bed, while the latter has been built according to the Concretor-Prome to slide-casting system. This method is also to be used for the Messaure dam above the Arctic Circle, which has a threshold height of 330 ft. and guards a reservoir containing 13 million cu. yards of water. One of the great advantages of the new Swedish dam-building system is that it cuts building time by 80 per cent.

Finally, it should be reported that during the jubilee year Swedish trunk-line cable-network builders will converge with their Finnish and Norwegian colleagues on their respective frontiers to connect up the three Scandinavian power systems with each other.

UNITED KINGDOM

FIRST BERYLLIUM PLANT. The first plant in Europe for the production of the metal beryllium in wrought forms is to be established at Birmingham, England, by the Metals Division of Imperial Chemical Industries Ltd., of Millbank, London, S.W.1. Designed to produce semi-fabricated forms of the metal, such as rod, tube and plate, and finished machined parts, the plant is expected to come into production by the end of 1959.

Its first task will be the execution of a production scale contract placed with I.C.I. by the United Kingdom Atomic Energy Authority as part of a development project. Spare capacity may later find additional outlets for this unusual metal, in which aircraft and missile designers are showing considerable interest.

Interest in beryllium as a nuclear engineering material has been intensified by the need for a metal which will perform satisfactorily in the higher operating temperatures envisaged in advanced nuclear reactors of the Calder Hall type. For the present programme of Britain's nuclear power stations, special magnesium alloy materials are used for sheathing (or "canning") the nuclear fuel. To increase the efficiency of this type of reactor, canning materials must be used which retain their strength at high operating temperatures. Because of its unique combination of attractive nuclear engineering properties, beryllium has been chosen by the Industrial Group, U.K.A.E.A., for the fuel canning in its Advanced Gas-cooled Reactor.

Outside the nuclear engineering industry, beryllium is likely to be of interest where a combination of light weight and high strength, or light weight and an unusual degree of rigidity is needed.

INSTRUMENTATION

(Continued from page 98)

automatic processes and supervisory warnings also, but in addition have instruments for thickness control and measuring and counting.

Comments given in replies

A manufacturer of cranes, boilers, plate and tank work states "considerable savings are effected with the aid of a smoke-density recorder, possibly as much as 5 per cent in fuel consumption. Steam-air flow instruments contribute towards perfect firing conditions, and aid staff in meeting widely fluctuating steam demands. Poor firing could lower efficiency by up to 10 per cent. Feedwater temperature, held to a maximum by visual observation of the instrument results in lowering boiler plate stresses set up by widely fluctuating temperatures of water entering the boiler, helps maintain smoother steam generating conditions and saves fuel".

"Oil pumping, heating and pressure gauges provide the staff with means to set up proper combustion conditions. Efficiency firing depends on maintaining maximum oil temperature and pressure. Savings from other quarters could be quickly eliminated if oil temperature and pressure get out of hand. Proper instrumentation enables the operating engineer to set up a necessary log-sheet of operations, and permits operating with less staff due to close control of shift routine".

"In the boiler room proper instruments kept in good order permit a closer watch on the staff at night on holidays and weekends—a great help when operating with minimum staff. Boiler operation could be simplified by direct boiler water analysis at the boiler. However there has been no improvement in boiler water testing for many years. A direct reading combination alkalinity-density and hardness instrument is still to be devised".

A maker of electronic instruments and controls comments that "numerical machine-tool control provides reductions in manufacturing costs of from 80 to 90 per cent. Other instrumentation is either essential to business or provides a minimum of 10 per cent reduction with the over-riding principle that it must pay for itself in one year".

"The importance of control and instrumentation in the process industries has not been sufficiently realized . . . numerical control in the machine-tool field will provide during the next few years the most amazing and exciting development in metal-working equipment that has occurred during the past decade . . . industries with foresight expecting to be in business five years hence must look to electro-mechanical types of control in the machine tool, process and nuclear reactor fields."

A manufacturer of compressors, drills, mine hoists pumps and pulp and paper equipment believes the trend today is towards greater instrumentation in many new fields. There is some danger, he thinks, that instrument makers have a tendency to work in too many extremely fine details in their instrumentation, sometimes overlooking the basic requirements and basic operating conditions.

A metal manufacturer turning out aluminum products remarks that instrumentation in his industry is mandatory due to the close tolerances which govern product quality — properties of strength, hardness, ductility, conductivity, corrosion resistance etc. It is also important in point of view of plant safety, efficiency research, inspection and testing. He anticipates this use will increase as new products and operations develop and as new instruments become available. Improvements in measuring equipment and techniques must keep pace with needs for greater accuracy. Such improvements will be a continuing trend in the future made possible by the increased use of electronics.

Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

International Nickel Manitoba Project

The new nickel mining project at Thompson, Manitoba, is scheduled to start smelter out-put in July 1960, and to come into regular full-scale production at an annual rate of 75 million pounds in 1961. With some 2,000 men engaged on the project during 1958, sinking of the 2,100 ft. mine production shaft and of the development shaft was completed. Related underground developments were carried forward.

Construction of surface facilities at the plant proceeded somewhat ahead of schedule. The production shaft headframe was readied for installation of the permanent hoists, the building for the mill and for the connected mine changehouse was completed, and work progressed on the smelter. The 500-ft. stack to disperse waste gases and to supply draught to the smelting equipment was finished. The compressor building and most of the service buildings were virtually completed. Yard grading, sewer, water and power distribution installations, and the construction of yard trackage, proceeded according to plan.

At Kelsey, 53 miles northeast of Thompson, construction of the power plant by Manitoba Hydro-Electric Board on the Grand Rapid of the Nelson River progressed satisfactorily.

The townsite situated astride the Burntwood River, two miles from the plant area, began to be transformed into the town of Thompson, which has been planned for an initial population of 8,000. Installation of the roads, sewer and water lines, and of the power distributing system, was on schedule. Construction has started on a water treatment plant and the town sewage disposal plant, and is about to start on the first of the four schools in the townsite and on a hospital to be operated by the Company.

Some B.C. Projects Proposed

In a list of industrial expansion projects proposed by British Columbia industries, and published by the British Columbia government, there are the following intentions expressed:

Primary steel: The Consolidated Mining and Smelting Company Limited was investigating the possibility of smelting pig-iron, using mine tailings from the Kimberley mine, which contain millions of tons of iron ore.

Flakeboard, fine papers: The Powell River Pulp and Paper Company Limited plans two new industries. The first would be a flakeboard mill with a capacity of 100,000 sq. ft. daily, and employing 40; the second, a fine paper mill employing 70 people.

Among projects under way, representing industrial expansion in the province, the following are listed:

Crown Zellerbach Canada Limited has a new corrugated paper box factory completed in 1959. Celgar Development Company will have a new pulp and lumber operation. The pulp mill will have a capacity of 500 tons daily, and will employ 325 in the pulp mill and 100 in logging and sawmilling. Completion is scheduled for 1960.

Wrights-Canadian Ropes Limited will complete in 1959 the expansion of a plant to manufacture a new product: prestressed wire rope. The plant's capacity will be 200 tons.

Air line: A new servicing base for turbine aircraft, with a new hangar and maintenance facilities, is to be completed in 1960.

Glass containers: Dominion Glass Company has underway a $4 million warehouse section, with main plant to follow.

CANADIAN DEVELOPMENTS
of 1958 will be reported in
THE ANNUAL REVIEW, 1958
May issue of
THE ENGINEERING JOURNAL

Private and Public Investment, 1959

The government has reported on the outlook for 1959 in private and public investment in Canada and summarized the results of a recent survey of capital spending intentions.

For the fourth year in succession, the minister of trade and commerce anticipates, capital investment in Canada will exceed $8 billion, a more than three-fold increase in a period of twelve years.

Intended outlays on construction and machinery, including repairs, are reported at 11.1 billion dollars. Within the total program, the principal increases appear in commercial and institutional building and government projects. Commercial construction will apparently go ahead more rapidly than ever. There is little change indicated in the rate of capital spending for a broad range of industry, including agriculture, forest and mineral extraction and processing, secondary manufacturing and transportation and communication. However, fuel and power industries have indicated a somewhat lower level of capital expenditure.

The minister of trade and commerce said that the rate of anticipated expenditures for 1959 indicates a continued expansion in industry. As a proportion of total national output, anticipated outlays for new plant and equipment compare favourably with levels in most post-war years.

What Goes On

Thermal Plant at Saint John, N.B.

Construction was due to begin in March 1959 on the new thermal electric generating plant in Saint John. The plant is estimated to cost 17 million dollars—a portion of the estimated $100 million program forecast for the entire district. Scheduled to be in operation for 1961, the plant is to be built in the Courtney Bay area of St. John.

Recent discussions indicate many other changes for that area.

Steep Rock Mines

On the "C" ore zone which the Company has leased on a royalty basis to Caland Ore Company Limited, Canadian subsidiary of Inland Steel, Steep Rock's President reports that the property is being prepared for open pit mining in 1960. Production from the Caland Mine is scheduled to build up from 750,000 tons in 1960 to a required minimum of 3,000,000 tons annually.

International Channel Improvements

Under an agreement between the United States and Canada, a cut-off channel will be constructed in the St. Clair River between Lake St. Clair and Lake Huron to eliminate the sharply curved channel known as the Southeast Bend. The cut-off channel will be six miles long, 700 feet wide, and will have a minimum depth of 27 ft. It will provide for two-way traffic in a straight line in place of the sharply curved channel and it will improve considerably ease of navigation in the St. Clair river.

The United States will pay for the construction work which will be done under the supervision of the U.S. Army Corps of Engineers. Canada's share consists in providing all the land required for the cut-off channel and in maintaining the channel after construction is completed. It passes almost entirely through Canadian territory, but Canada's sovereign rights over the area are protected by the agreement.

Ontario's $885.7 million budget

In the fiscal year ending March 31, 1959, the government will have carried out the largest works and service program in its history. In the provisions for the year 1959-60 there are these items among many others:

Education: An expenditure on education totalling $202.4 million; an appropriation of $1.2 million is being made for the introduction of a new and expanded system of aid to students of ability who are desirous of continuing their education beyond the secondary school level.

Highways. The appropriation for highways is $261.3 million. Among the important projects are: start on high-level bridge on Queen Elizabeth way crossing Welland canal at St. Catharines; acceleration of work on highway 401 to achieve its completion by 1963; work on the Rainy Lake causeway and on the extension of highway 120 west from Atikokan.

Mining. Total expenditure for assistance for the mining industry would be $6 million, including $1.5 million for mining access roads, and special payments totalling $3 million to mining municipalities.

Forestry. Appropriation for forest management, conservation and regeneration is $27.8 million, including $1.5 million for logging and forest-access roads.

Housing. Provincial cost of land assembly on rental-housing projects is provided by $6.5 million appropriation.

Hydro. Capital construction outlays in 1959 are estimated at $196 million.

Alberta's Budget for 1959

The total expenditure of the government will be $309.6 million. Some of the projects to be accomplished are as follows:

Agriculture: A sum of $705,000 has been provided for irrigation, drainage and flood control projects.

Education: $10.8 million are required to meet the basic needs of the University in Edmonton and in Calgary. Construction of the physics and chemistry building is to commence.

Public Works. Expenditures totalling $43 million are planned by the Department of Public Works.

Mines, minerals and oil. The sum of $1.9 million has been appropriated for the department to continue the administration of the development of natural resources.

Highways. Construction of highways, bridges and ferries will require the spending of $48.5 million. This includes $3 million for work on the trans-Canada highway and $4 million for roads to resources.

Developments in Saskatchewan

- A $1 million steel fabricating plant is to be built in Regina by the Dominion Bridge Company Ltd. Dominion Bridge expects to have the new plant in production before the end of 1959. The plant's main operation will be the fabrication of structural steel for buildings and bridges, but it will also warehouse a complete stock of steel supplies for Saskatchewan industries.
- A major expansion program being completed in May 1959 doubles the capacity of the Saskatoon Boiler Company Limited.
- The province's post-war industrial growth and its potential for future economic developments are being scrutinized by a group of Canadian and American research specialists. These consultants have been engaged by the Saskatchewan government to make an objective appraisal of the provincial economy and to suggest long-range programs to ensure the best development of the province's economic potential.

One phase of the research will be devoted to an analysis of resource development and expansion possibilities. The study will include industries based on forest resources, uranium, potash, clays, oil, natural gas and other minerals. Industries appearing to have favourable possibilities will be defined, and suggestions for promotional activities will be outlined.

- There will be a new industry in Moose Jaw which will involve an investment of about $500,000. A cold roll-form steel mill is to be established.

Need for Nuclear Power

"From 1965 onwards we hope nuclear electric stations will begin to supply some of our thermal requirements," Ontario Hydro chairman James S. Duncan said recently.

However, the production of nuclear energy at a cost that will compete with traditional methods of generation still awaits the solution of a great many engineering and technical problems, he said.

Inflation

Ontario Hydro chairman James S. Duncan, in a recent speech referred to inflation as a national problem which "dwarfs all others in its significance". The problem facing Canada, he said, is not one of runaway inflation, but one of gradual and progressive erosion of the purchasing power of our currency.

Canada's prosperity is largely based on foreign sales of basic commodities, such as newsprint, iron ore, copper, nickel, wheat and uranium. But natural resources are of value as an export only if they are competitive on world markets. If inflation is to be halted, it will, in Mr. Duncan's opinion be accomplished by the weight of public opinion. Sacrifices and discipline, imposed upon ourselves are necessary to safeguard the economic system and the way of life, he said.

Lift-Bridge at Burlington

The contract for construction of the $3.7 million vertical lift-bridge at Burlington, Ontario has been awarded to Bridge and Tank Company of Canada.

The largest and longest of its type in Canada, it is a combination railway and highway structure spanning the Burlington Beach ship channel. The new bridge will be 370 ft. long and 51 ft. wide. Massive towers from which the bridge will be suspended will be more than 200 ft. high. In raised position the bridge will give a clearance above water of 120 ft. for ship passage.

C.N.R. extends marshalling system

Another link in the chain of new marshalling yards being built across Canada for the Canadian National Railways will be provided at Toronto, if federal legislation is obtained. It will complement the three hump yards under construction at Winnipeg, Montreal and Moncton.

Algoma Bloom and Plate Mill

The only combination bloom and plate mill on the North American continent was completed and test rolling began in March 1959, by the Algoma Steel Corporation Limited, Sault Ste. Marie, Ont.

With this installation, Algoma has become one of Canada's leading heavy industries.

An electronic card program controls mill operations. This system in the mill can readily be expanded to include card control program for other mill functions such as speeds, reversal of drive, speed of mill tables, operation of manipulators, etc., or the entire mill operation.

For rolling slabs, the mill is fed with massive 30-ton steel ingots from soaking pits. Covers of the new pits can be removed by remote control. The ingot is automatically selected and lifted out, transferred to receiving table, automatically weighed and turned around.

In the rolling operation it is rolled into a bloom or slab. The blooms are transferred to other mills for manufacture of structurals or other products, or they may be re-rolled in the new mill into plate or tube rounds.

The huge mill is powered by two 4,000 hp. motors. It is used as a 2-high assembly for rolling slabs and a 4-high assembly for rolling plate. Industrial television is being installed.

The dual purpose mill has capacity to roll 500,000 tons of steel ingots a year and also to re-roll the resultant semis into 350,000 tons of plate and/or tube rounds.

In addition to increasing the Company's steel rolling capacity, this mill provides greater flexibility in operations. Its capability of producing tube rounds releases existing facilities for other production as required.

Projects yet to be completed by Algoma are: a large blast furnace turbo blower which, with the boiler recently completed, will allow retirement of all blast furnace blowing equipment more than 16 years old; a new and more powerful drive for the reversing roughing stand of the rail and structural mill; and a new continuous reheating furnace for the same mill, replacing old furnaces.

Investigations are now being made into the advisability of installing a universal beam mill at the steelworks to produce wide flange beams in sizes most used in Canada.

The Orenda Engine

The *Journal* has been informed of the following, as a discussion of the article titled "Propulsion", by F. H. Keast, *(Fifty Years of Aeronautical Engineering)* which appeared in the February issue of *The Engineering Journal*, Page 37.

(a) The ORENDA was designed to a very simple and clear specification which called for a maximum ground level static take-off thrust of 6,500 pounds;

(b) ORENDA No. 1 regularly achieved and sometimes exceeded the specified thrust of 6,500 pounds;

(c) This prototype engine established some kind of a record for reliability by completing 784 hours of rigorous "type test" type of running without being removed from the test stand. This was achieved after almost 100 hours of previous running and two partial strips for inspection but without any modifications. A further interesting fact is that this extraordinary run was terminated abruptly by a bolt and package of Schick injector razor blades being accidentally sucked into the engine intake.

CONDUCT OF TECHNICAL SESSIONS AT 1959 ANNUAL MEETING, E.I.C.

As a result of many comments from members attending past annual meetings and careful consideration by the Committee on Technical Operations, some changes will be made in the conduct of technical sessions. An outline of procedure adopted for the coming Annual Meeting is as follows:—

1. As far as possible, a session chairman will not take more than one minute for the introduction of the author.
2. *The author will be allowed 15 minutes for the presentation of his paper.* Each author is asked to make his presentation based on a summarization of his paper adapted to oral presentation. (Remember papers are to be preprinted and available well before the Annual Meeting). *There will be a warning signal under the control of the chair which will notify a speaker when he has one minute remaining. The speaker will be similarly notified when his time is up and must then close his presentation promptly.*
3. *Authors* will be provided with ten preprints of their papers as soon as possible and *are asked to invite prepared discussion* from those they think can contribute to the value of the treatment of which the paper is the broad framework. *The appropriate Engineering Division chairman should be advised promptly of the names of invited discussors* so that session chairmen can be notified. *The Engineering Divisions* of the Committee on Technical Operations *will also invite discussion on Annual Meeting papers.*
4. Discussors are asked to make known to the session chairman their desire to participate in discussion, at the first opportunity before the opening of the session.
5. Time will be allotted for discussion from the floor, if at all possible, but preference will be given to those who have indicated their desire prior to the opening of the session.
6. *The maximum time allotted for any discussion will be limited to 5 minutes and the warning-signal procedure noted in (2) will be utilized.*
7. *The author will be allowed not more than 7 minutes for verbal closure. The warning-signal procedure noted in (2) will be utilized. However, the author's written closure can be of such length as necessary to deal appropriately with the ensemble of discussions.*
8. *Session chairmen will close their sessions at the scheduled time.*

See annual meeting notice elsewhere in this issue.

Month to Month

News of the Institute and the Profession

COMMENT
CORRESPONDENCE
ELECTIONS
AND TRANSFERS

ROYAL VISIT — 1959

H.R.H. The Prince Philip has graciously consented to address engineers and scientists at a luncheon at the Royal York Hotel, Toronto, at noon on Monday, June 29th. Groups participating are

Canadian Aeronautical Institute
Canadian Council of Professional Engineers
Canadian Institute of Mining and Metallurgy
Chemical Institute of Canada
Engineering Institute of Canada

Applications for tickets should be made immediately to

Engineers and Scientists Committee
P.O. Box 62
Postal Station Q
Toronto 7, Ont.

The ticket allotment will be one to a person and the applicant must indicate his registration with one of the organizations participating. Tickets are non-transferable.

A cheque in the amount of $5.00, payable at par in Toronto, must accompany each individual application. Cheques should be made payable to the Engineers and Scientists Committee.

Distribution of tickets will be made on June 1st taking into consideration

(1) Order of receipt of application
(2) Fair distribution to participating organizations

CONFEDERATION

A Progress Report

The joint sub-committee on Confederation met again in Montreal on Tuesday, March 10. The report on Confederation was studied again and a few minor suggestions were made so that the report could be reissued as a completely unanimous joint report.

In the form which it is now being submitted to the Canadian Council and resubmitted to the Council of the Institute, it has been streamlined somewhat with the objective of making it clearer for final presentation to the membership.

The committee quickly reached unanimity on all points and since the meeting the report has been retyped and sent to the various members of the joint committee, all of whom have sent in their approval. Thus it is possible to report to the membership that the report in what the committee expects will be its final form is now complete. It will be submitted to the Council of the Institute at its meeting in Montreal in April and will be considered by the Canadian Council at its annual meeting in May. It will be submitted to the membership shortly thereafter.

The sub-committee believes that the report in its present form is clear and concise and that the members will have little difficulty in following it in every detail. It is the joint committee's belief that the report provides an adequate basis for the provisional council, now referred to as the Engineers Confederation Commission, to conclude all the planning necessary to bring Confederation to pass.

ANNUAL GENERAL AND PROFESSIONAL MEETING

The Engineering Institute of Canada

ROYAL YORK HOTEL, TORONTO,

June 8, 9, 10, 1959

TECHNICAL ACTIVITIES

Members will be interested to know about several new features for the technical program at the June 8-10, 1959, Annual Meeting in Toronto, which your Committee on Technical Operations has planned.

Thanks to the several active Engineering Divisions a well-balanced program of technical papers has been arranged. Many of the papers are tied closely to the basic theme of the meeting—BY THE RIVER TO THE SEA—but the remainder cover new developments of interest to engineers in every field of our profession. There is to be a half-day panel session, with five notable Canadian educationalists, economists and engineers, on "The Economic Impact of the Seaway". Another exciting feature will be a four-part symposium on the far-ranging "Headquarters Computation Centre for Ontario Hydro".

This issue of *The Engineering Journal* carries abstracts of all papers which will be included in the program. You will thus have a chance to know something about the technical papers to be presented, and know it in advance.

Moreover, annual meeting papers are to be preprinted and made available to members requesting them, at a nominal cost, well in advance of the meeting. They will also be available at the meeting. Any member can thus secure a copy of a paper in which he is interested in ample time to prepare a discussion and submit it either to Headquarters by June 1st, or to the chairman of the session at which the paper is being presented, prior to presentation.

The success of technical sessions depends on your attendance, on your contribution to discussions. Why not make the Annual Meeting in Toronto the best ever?

PLEASE REFER TO PAGE 93 FOR ABSTRACTS OF THE TECHNICAL PAPERS TO BE PRESENTED.

THE NEXT ISSUE OF THE JOURNAL WILL HAVE THE COMPLETE PROGRAM OF EVENTS OF THE ANNUAL MEETING, 1959.

The Speakers Panel

Conference Banquet

Southern Ontario Regional Conference

The second Southern Ontario Regional Conference was a complete success, with attendance equalling last year's. The conference was held in the Royal Connaught Hotel, on Saturday, March 14 in Hamilton.

Following the late morning registration, the luncheon at one o'clock featured a very interesting panel discussion that captivated the audience. The topic was "What's on the Horizon for John Smith, B.A.Sc., Class of '65". The moderator was H. L. Shepherd, manager, salary administration and personnel development, Canadian Westinghouse Co. L. D. Dougan, vice president, operations, Polymer Corporation, stated what Canadian industry needed and required of this young engineer. S. D. Rendall, superintendent of secondary education, Department of Education, Ontario, outlined what is now being done in the way of scholarships, bursaries, and education to help John Smith prepare for university. Lastly, Professor L. S. Lauchland, head of the Department of engineering science, University of Western Ontario, emphasized the academic education of the student engineer, and said that this education is subject to changing world conditions. Professor Lauchland summed it up very appropriately, "Engineering is a journey and not just an experience". An enthusiastic question and answer period followed.

The remainder of the afternoon was occupied with technical papers.

While the men were listening to these technical papers, the ladies were enjoying a fashion show under the capable direction of Mrs. Joyce Saunders, Program Convenor.

The conference banquet was held in the Crystal Ballroom with a capacity crowd. After a delicious turkey dinner, Hugh Seely, chairman of the Hamilton Branch, E.I.C., introduced the head table to those present. Dr. Garnet Page, general secretary of the E.I.C. expressed his satisfaction at being present for this conference.

Stuart Armour, economic advisor to the Steel Company of Canada Ltd., was guest speaker. His subject, "Why Buy Made in Canada" was indeed applicable to every engineer present.

An informal dance in the Crystal Ballroom concluded the conference.

E. W. Hill, M.E.I.C., very capably directed and organized the Conference for its second successful year.

Ladies Coffee Hour: Mrs. H. L. Hillgartner, Mrs. Joyce Saunders, Mrs. R. H. Stevenson, Mrs. J. M. Skinner.

Trophy for Engineers

The Clement Mathew Anson Trophy is an innovation for the annual Plumbers' Ball at McGill University. It was awarded for the first time this year to the department of engineering who made the best showing in the exhibits presented on the night of the ball. The winner was the metallurgy department, with a display of perpetual motion. Dr. L. Austin Wright of the E.I.C., substituted at the ceremony for C. M. Anson who was in London, England. Receiving the trophy was G. M. Desjardins, president of the McGill Engineering Undergraduate Society.

Dr. Anson is the one who thirty-three years ago founded the Plumber's Ball and was responsible for its being called by that name. At that time he was president of the Engineering Undergraduate Society. The ball was a challenge to those who doubted that the engineers could carry off a social function of quality. From that day it has been the outstanding social event of the whole university.

Staff Changes

Two members of The Engineering Institute staff left the employ of the Institute on February 28, 1959, for other positions.

They are: Henry P. Gatin, director of membership services, who has been at E.I.C. Headquarters since the fall of 1956; and John A. McLaren, eastern field secretary, whose service through the Toronto office had been available to eastern members since early 1958.

Elections and Transfers, for February, 1959, are listed on Page 133 of this issue.

NORTHERN ONTARIO REGIONAL CONFERENCE

of The Engineering Institute of Canada

Nickel Range Hotel, Sudbury, Ont.

Saturday, April 25, 1959

SOMETHING NEW

This conference is the first of its kind in this region sponsored by the E.I.C. All northern Ontario E.I.C. and A.P.E.O. members and their ladies are urged to attend. A special Sudbury Branch conference committee has made comprehensive plans and arrangements for your pleasure and convenience. The guest speakers, papers presentation, and social program will be stimulating and enjoyable for both the engineers and their ladies and the conference will present an opportunity for all northern Ontario members to meet.

12.00 - 1.15 p.m.	MEZZANINE FLOOR	REGISTRATION
12.00 - 1.30 p.m.	MEZZANINE FLOOR	BUFFET LUNCHEON, Men and Ladies
1.30 p.m.	BALL ROOM	GENERAL ASSEMBLY and welcome from the Sudbury Branch.
1.30 - 4.15 p.m.	BALL ROOM	CONFERENCE PROCEEDINGS

TECHNICAL PAPERS

Engineering Future of Canada in the Next Twenty Years

1. ENERGY—Nuclear, Hydro-Electric, Carbonaceous, Solar.
   J. L. OLSEN, *Canadian General Electric Co., Kingston.*
2. TRANSPORTATION—Land, Air, Water
   A. LIGHTBODY, *Assistant Manager, of Research, Canadian Pacific Railways.*
3. DEFENSE
   MAJ. GEN. W. S. MACKLIN, *Ottawa, Ont.*

Concurrently with technical session, an attractive Ladies' Program will be held at the Copper Cliff Club. Note: Arrangements will be made for dressing accommodation for visiting ladies.

6.00 p.m.	LOUNGE	RECEPTION AND COCKTAILS as guests of the Sudbury Branch.
7.00 p.m.	BALLROOM	CONFERENCE BANQUET. Evening guest speaker. DR. GARNET T. PAGE, *General Secretary of the Engineering Institute.*
9.30 p.m.	BALLROOM	E.I.C. REGIONAL CONFERENCE DANCE Dress informal.

All E.I.C. and A.P.E.O. members and their ladies and guests are cordially invited

PLAN TO ATTEND!!

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

Sir Claude Dixon Gibb KBE, FRS

One of the all time "greats" of the engineering profession died suddenly on January 15th, 1959 at the airport in Newark, N.J. He was Claude Dixon Gibb, Chairman and Managing Director of C. A. Parsons & Company, Limited, Newcastle-upon-Tyne, England.

Sir Claude was well known to Canadians and in particular to members of the Engineering Institute. He was a frequent visitor to Canada, and had a host of friends here. On two occasions he delivered lectures to a series of branches of the Institute, and it is noteworthy that he broke all attendance records at each branch. As a lecturer and a discusser of technical problems in his diversified field he was without peer or equal.

Sir Claude's health was such that for years he knew he was "living on borrowed time," but he carried on his duties as if nothing were wrong. He was always cheerful, interested in everything around him, helpful to other people, and charming in a way that brought him new friends and greatly enhanced old friendships.

Few engineers possess the breadth of his interests, his knowledge and his achievements. He was a great engineer and an outstanding industrialist. It was said by those who should know that although he was the chief administrator of his company, he was still the best engineer in the organization.

The Engineering Institute recognized his outstanding character and achievements by making him an Honorary Member at the Annual Meeting in Quebec in 1958.

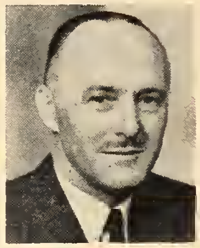
This distinguished gentleman was born in Adelaide, Australia in 1898. He was graduated from the South Australian School of Mines (Adelaide University) and later did post-graduate study at London and Durham Universities, to obtain his doctor's degree.

From 1917 to 1919 he was a pilot in the Australian Flying Corps, and in the second world war was Director General Armoured Fighting Vehicles and Chairman of the British Tank Board. In this post he led the team that developed the Centurion Tank. He developed and brought into production the British 17 pounder, and as well was responsible for all British weapon production.

After the first world war 1920-1923 he was senior research assistant in the engineering laboratory University of Adelaide. In 1924 he went to England and started his industrial training as a fitter at the Heaton Works of C. A. Parsons and Company Limited. In rapid succession he became chief engineer and director of the company (1929), General Manager 1937, Joint Managing Director 1943 and in 1945 Chairman and Managing Director, the position he held at the time of his death.

Also he was Chairman of the Reyrolle Company, and of the Nuclear Power Plant Company, Limited.

In 1945 he was honored by the King, with a knighthood, for his war work, and in 1956 he was made Knight of the British Empire for his outstanding contribution to the development of atomic power. He was made a Fellow of the Royal Society, for original research and design, new methods of manufacturing steam turbines and for his armament work.



Sir Claude Gibb,
KBE, FRS,
HON. M.E.I.C.

He has presented innumerable technical papers, and has received many awards for them, from many parts of the world.

Sir Claude was a great man. The profession is justifiably proud of him. It is tragic that he should have been cut off at so young an age, and the world deprived of his continued good works. Few men have made so deep a mark on industry and on their profession. The world is much better because of him and there is every reason to believe that his influence will continue for years by virtue of his good example.

"I shall not look upon his like again."

L. A. W.

Clive Joyce, S.E.I.C. died on November 15, 1958.

Born on May 28, 1933, he attended Queen's University, graduating with a B.Sc. (Hons) (Chem.) degree in 1957.

He was awarded his M.Sc. degree in chemical engineering at Queen's University in 1958. He had later started on research in fluid flow through porous media. He was on a National Research Council scholarship.

Alex. Alfred Plummer, M.E.I.C. died April 24, 1958.

He was born on September 19, 1889 in Toronto, Ont.

From 1904 until 1910 he was employed in railway, lumber and municipal engineering in Ontario and British Columbia, and from 1912 to 1913 he was partner and superintendent of Marshall, Plummer & Company, engineers and contractors. In recent years the firm was designated as A. A. Plummer Company Ltd., Vancouver, B.C.

Herbert Alcock Elgee, M.E.I.C. died early in 1958 in England.

He was born on December 7, 1867 in India and received his B.A. degree at Trinity College, Dublin. He also attended engineering school at Trinity College.

From 1902 until 1913 he was employed as engineer and agent for various harbour works in Singapore, South Africa and British Columbia. In 1921 he became chief engineer with the Back Bay Reclamation Scheme, India, returning to England in 1928.

Richard F. Davy, M.E.I.C. died on November 29, 1958 in Victoria, B.C.

Born in Toronto on November 7, 1875, he carried out extensive explorative surveys for the Canadian government in Quebec.

In 1928 he became assistant engineer with the Department of Public Works, Canada, and in 1941 retired from the Department at Victoria.

T. E. Gilchrist, M.E.I.C. of Peterborough, Ont., died on September 26, 1958.

Born in Ottawa, Ontario in 1888, he graduated from McGill University in 1910 with a B.Sc. degree.

He worked with the Canadian General Electric Company for many years in Peterborough. He had joined the Canadian General Electric Company in 1910 in the testing department.

James Walsh MacMahon, M.E.I.C. died on October 4th, 1958 in Montreal.

He was born in St. Catharines, Ont., on November 11, 1883. He graduated from McGill University with a B.Sc. degree.

Mr. McMahon was made a Life Member of the Institute in 1949.

John J. Murphy, M.E.I.C., of Ottawa, Ont., died on June 28, 1958.

Born in Halifax, N.S. on November 13, 1874, he had his early schooling there. Later he studied at the La Salle, Cambridge House Academies and Kings' College, and attended an engineering course 1892-93.

His early career included work in the Provincial Engineering Office, Halifax, and for the Nova Scotia Southern Railway. Later he was engaged in the Welland ship canal project at Port Colbourne, Ont. In 1928 he became assistant to lock engineer, Welland ship canal. In 1932 he was in the division engineers' office. His engineering service to the Welland canal and the Trent canal extend over many years.

Mr. Murphy had completed more than fifty years of membership in the Institute, having joined in 1890.

A. Q. Niazi, JR.E.I.C. died in 1958 in Pakistan. He was born in Pakistan on January 1, 1925 and from 1932 to 1940 attended Panjab University schools in that country.

In 1947 he went to McGill University, graduating in 1950 with a B.Sc. degree in civil engineering. In 1957 he served as sub divisional officer, P.W.D. (B.&R) in Lahore, West Pakistan.

Personals

M. J. des R. Tessier M.E.I.C.

W. J. Bichan, M.E.I.C.

W. J. Bichan, M.E.I.C. (B.Sc., mining, London 1932) of M. J. Boylen Engineering Services, is in Toronto after having spent two years in management of Advocate Mines Ltd, Baie Verte.

F. J. Slominski, M.E.I.C. (B.Sc., civil, Saskatchewan 1925) of Poole Construction Company Limited, Edmonton, has transferred from the Regina Branch. He is a vice-president of the company and district manager of the Saskatoon District.

M. J. desR. Tessier, M.E.I.C. (B.A.Sc., C.E., Ecole Polytechnique 1909) has retired as managing director of the Better Business Bureau of Quebec.

J. J. Kaller, M.E.I.C. (London, England 1950) has accepted the position of administrative engineer with the Corporation of the District of Burnaby, B.C.

V. M. Wallingford, M.E.I.C. (B.A.Sc., civil, Toronto 1944) is chief engineer of the Arbec-Campbell group of Companies, with office in Montreal. He leaves Baie Comeau, Quebec, where he was with Canadian British Aluminum Co. Limited, and Chairman of the local Branch of the E.I.C.

John Stephenson, M.E.I.C. has retired as plant engineer, National Steel Corporation Hamilton, Ont. He is now with the water works design division, City of Hamilton.

W. E. John Turke, M.E.I.C. (civil, Zurich, Switzerland, 1936) has recently been named a senior associate of the firm of Surveyer, Nenniger & Chenevert, Montreal. He has been in charge of structural design and of complete projects with the firm since 1941.

Jack Hahn, M.E.I.C. (B.Eng., elec., McGill, 1947) has become a senior associate of the firm Surveyer, Nenniger & Chenevert, Montreal. He is on the executive committee of the Montreal Branch of the Institute for 1959.

A. C. Davidson, M.E.I.C. (B.Sc., civil, 1935; elec., 1936; Manitoba; M.A.Sc., Toronto, 1949) has been elected chairman of the Toronto Branch of the Institute. He is assistant professor in the department of civil engineering at the University of Toronto.

W. J. Manning, M.E.I.C. (B.A.Sc., civil, Polytechnique, 1927) of the Department of Transport since 1940, has been promoted from chief of aids to navigation to the post of director, marine services.

A. Laing, M.E.I.C. (B.Sc., civil, McGill 1930) has recently been appointed chief of aids, marine services branch of the Department of Transport, Ottawa.

Carson F. Morrison, M.E.I.C. (B.Sc., civil, Saskatchewan 1925; M.Sc., structural, McGill 1927) has been appointed editor of *Canadian Consulting Engineer,* a Hugh C. MacLean publication. He will remain in his position of professor and head of the department of civil engineering, University of Toronto.

Alan Wyatt, M.E.I.C. (mechanical, R.N.E.C., Keyham, 1951) of Ontario Hydro is on loan to Atomic Energy of Canada Limited, working on the CANDU project, as design engineer, nuclear power plant division.

W. R. Astrop, M.E.I.C. (B.A.Sc., civil, Toronto 1950) of C. C. Parker and Associates, has been named assistant bridge engineer.

Douglas R. Wilson, M.E.I.C. (B.Eng., civil, McGill 1951) has been appointed section head, sewage and water department, R.C.A.F. headquarters, Ottawa.

F. De Francis, M.E.I.C. (B.Eng., civil, McGill 1951) has joined Harbour Steelworks Ltd., St. Sulpice, Que., as chief engineer.

Elson H. Hanson, M.E.I.C. (B.Sc., civil, Saskatchewan 1953) is a municipal engineer of the municipality of Fort Garry, Man.

Jack Hahn, M.E.I.C.

W. E. John Turke, M.E.I.C.

W. R. McEown, M.E.I.C. of the Department of Trade and Commerce has been named district inspector, electricity and gas, Toronto standards division.

Edward G. Taylor, M.E.I.C. (B.Sc., civil, Queens, Belfast, 1948) has been appointed chief utilities and roads engineer design division with the Directorate of Works (Army), Department of National Defence, Ottawa.

W. R. McEown, M.E.I.C.

W. E. MacDonald, M.E.I.C.

C. H. Davis, M.E.I.C. (B.Sc., Sir George Williams College, 1937) of the Bell Telephone Company of Canada has become equipment engineer, customer services, eastern area.

W. E. MacDonald, M.E.I.C. (B.Sc., mining, N.S.T.C. 1950) of the Dominion Coal Company Limited, has been appointed district superintendent, district No. 3, New Waterford, N.S.

Karl Pozsonyi, M.E.I.C. (dipl. civil, Budapest) has joined E. M. Peto Associates Ltd., Toronto, as soil engineer.

Morley M. Muth, M.E.I.C. (B.Sc., civil, Sask. 1956) has joined the design branch of the Manitoba Department of Public Works.

A. C. Davidson, M.E.I.C.

J. J. Kaller, M.E.I.C.

R. J. Coghlan, M.E.I.C. (B.Sc., mech., Saskatchewan, 1943) formerly resident engineer for Bailey Meter Company Limited, London, Ont., has been promoted to district manager for the company, in the Atlantic Provinces. His headquarters are in Halifax, N.S.

O. I. Johnson, M.E.I.C. (B.Sc., civil, Saskatchewan 1948) has been appointed maintenance superintendent, Kimberley fertilizer department of The Consolidated Mining and Smelting Company, Trail, B.C.

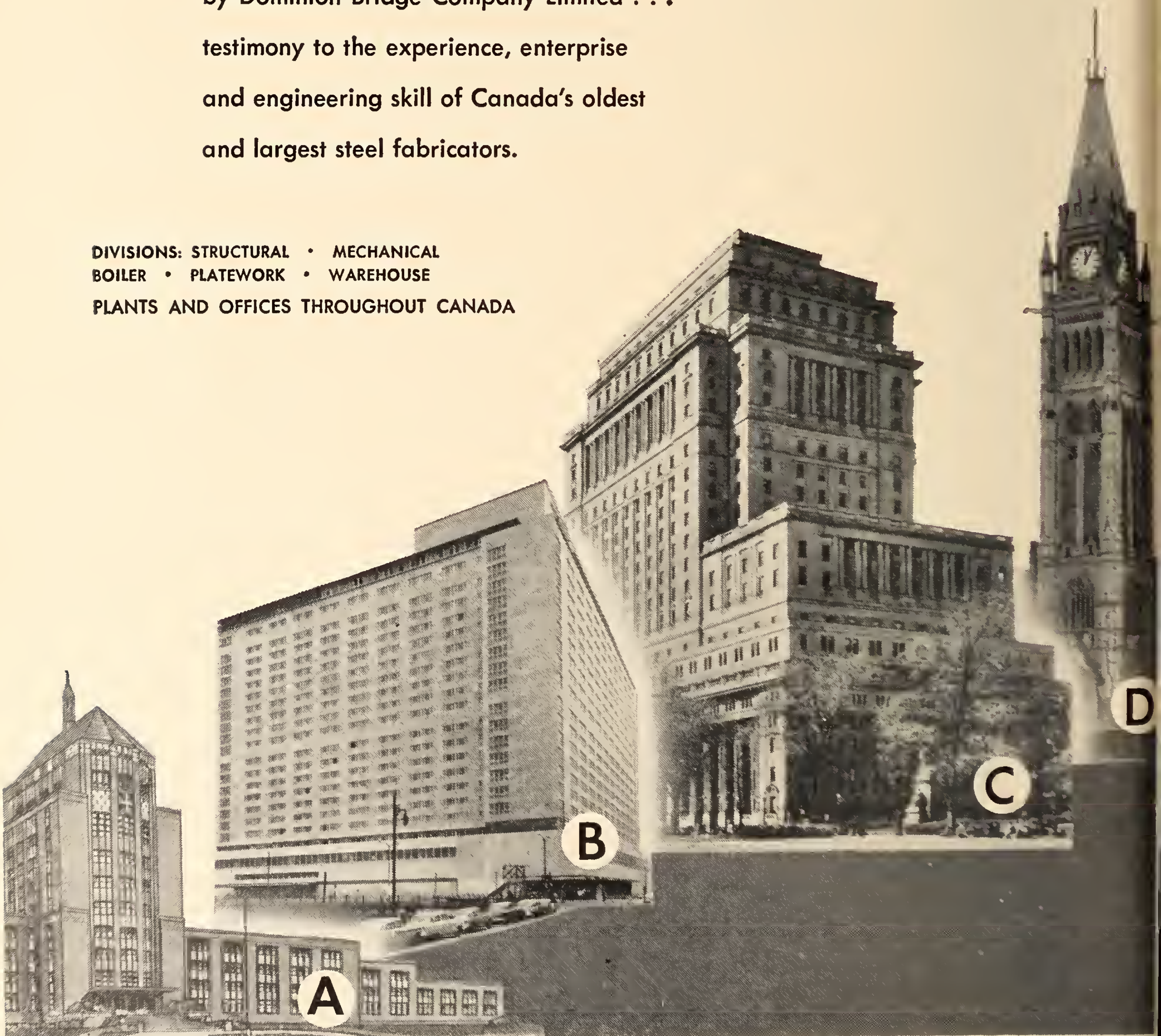
Donald P. Ryan, M.E.I.C. (B.Sc., mech., Toronto 1949) has been appointed Ontario district representative for Precipitation Company of Canada Limited, Toronto.

James E. Smith, M.E.I.C. (B.A.Sc., mech., British Columbia, 1949) has been appointed chief, Norden products sales, Canadian Pratt & Whitney Aircraft, Montreal.

Can you identify these

Dominating the skylines of Canadian cities, these buildings new and old reflect the nation's striking growth. Can you identify them? Like thousands of other well-known buildings from coast to coast, they contain steelwork fabricated and erected by Dominion Bridge Company Limited . . . testimony to the experience, enterprise and engineering skill of Canada's oldest and largest steel fabricators.

DIVISIONS: STRUCTURAL • MECHANICAL
BOILER • PLATEWORK • WAREHOUSE
PLANTS AND OFFICES THROUGHOUT CANADA



• PERSONALS

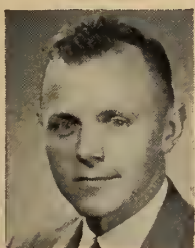
Hans Ulmann, M.E.I.C. (dip. Switzerland 1925) has been appointed manager of the new Gear Products Division of Dominion Engineering Company Limited, Montreal.

G. E. Plant, M.E.I.C. (B.A.Sc., mech, British Columbia 1950) of Dominion Engineering Company Limited, Montreal, has been appointed sales manager of the new Gear Products Division.

R. E. Smallwood, M.E.I.C. (B.A.Sc., mech, Toronto 1935) has recently been appointed product engineer in the new Gear Products Division of Dominion Engineering Company Limited, Montreal.

Alex Campbell, M.E.I.C. (B.Sc., M.Sc., civil, McGill, 1924, 1926) vice-president and manager of the Western Division of Dominion Bridge Company Limited for the past seven years, retired on March 1, 1959. He started with the company in 1920.

Hans Ulmann, M.E.I.C.



G. E. Plant, M.E.I.C.

P. A. Duchastel, M.E.I.C. (B.Eng. McGill 1938) is the new chairman for the Quebec Branch of the Institute. He is chief engineer with the Quebec Power Company, Quebec.

Alex. Campbell, M.E.I.C.

P. A. Duchastel, M.E.I.C.

R. F. Routledge, M.E.I.C. (B.Eng. McGill 1947) is the new chairman for the Sarnia Branch of the Institute. He is associated with Imperial Oil Limited's Sarnia Refinery as technical superintendent.

R. F. Bailey, M.E.I.C., (B.Sc., Chem., Al-

R. F. Routledge, M.E.I.C.

R. F. Bailey, M.E.I.C.

Harold L. Steel, M.E.I.C.

R. D. Hall, JR.E.I.C.

berta 1941) supervisor of projects with Consolidated Mining & Smelting Company of Canada Ltd., Trail, B.C. has been elected chairman of the Kootenay Branch of the Institute.

Robert Hodgson, M.E.I.C. (B.Eng. mech, N.S.T.C., 1951) has transferred from Halifax to be area supervisor, mechanical department, with Imperial Oil Limited at Sarnia, Ont.

Roy F. E. Bunston, M.E.I.C. (B.Sc., elect. Queen's, 1942) is appointed industrial products manager with Burndy Canada Ltd, Markham, Ont.

John E. Laughlin, M.E.I.C. (B.Sc., civil, Saskatchewan, 1948) has transferred to the Department of Public Works, Ottawa, as assistant construction engineer.

Leslie Pallas, M.E.I.C. is group engineer for Gordon Hotels Ltd, in London, England.

• PERSONALS

Alfred H. D. Haiblen, M.E.I.C. (B.Eng., elec., McGill, 1946) president of Jedwin of Canada Limited, has been appointed secretary-treasurer of O'Day Associates of Canada Limited, Toronto.

O. van Deurs, M.E.I.C. (M.Sc., civil, Copenhagen 1943) has taken up the position of county engineer of Lampton County, Ont.

Robert L. Higgins, M.E.I.C. (B.Sc., mech., Louisiana, 1952) until recently with Canadian Utilities Ltd., Edmonton, has gone to Keyport, Wash., as supervisory electronic engineer at a naval torpedo station.

Harold L. Steel, M.E.I.C. is the new chairman for the Amherst Branch of the Institute. He is chief draughtsman, structural steel division, of Robb Engineering Works Limited, N.S.

Frederick Krug, M.E.I.C. president of Canadian International Power Company Limited, and vice president of Montreal Engineering Company Limited, is this year's recipient of the Gano Dunn Medal of the Cooper Union Alumni Association.

R. D. Hall, JR.E.I.C. (B.Sc. elec. Alberta 1948) is the new chairman for the Lethbridge Branch of the Institute. He is utility engineer with the City Hall, Lethbridge, Alberta.

H. Orlando, JR.E.I.C. (B.A.Sc., civil, Toronto 1953) project design engineer with the Ontario Department of Highways, has been transferred from the Kingston region to London, Ont.

A. L. Adams, JR.E.I.C., (B.Eng., elec., McGill, 1951) has recently been appointed electrical superintendent of Mannesmann Tube Company Ltd., Sault Ste. Marie, Ont.

R. J. R. Welwood, JR.E.I.C. (B.Sc., mining, Queen's 1950) former mine captain, Stanleigh Uranium Mining Corp. Ltd., is now a research engineer, Panel mine, Elliot Lake, Ont.

R. F. Critchley, JR.E.I.C., (B.Eng., mech., Saskatchewan 1955) has gone to England on an Athlone Fellowship, and is with Vickers-Armstrong (Engineers) Ltd. at Newcastle.

C. A. Clements, JR.E.I.C. (B.Eng., civil, N.S.T.C. 1954) of the Hydro-Electric Commission of Ontario, construction division, has become design engineer at Ontario Hydro's head office in Toronto.

Ralph Neil, JR.E.I.C. (B.Eng., civil, N.S.T.C. 1957) resident engineer with the Department of Highways, at St. John's, Nfld.

Stuart F. Lyon, JR.E.I.C. (B.A.Sc., civil, Toronto 1954) is now working on construction of the Inter-American highway in Costa Rica.

R. F. Gurr, JR.E.I.C. (B.Sc., mech., Queen's 1954) is project engineer, works engineering department, at the Aluminum Company of Canada Limited, Kitimat, B.C.

Jules Leonard, JR.E.I.C. (B.A.Sc., civil, Polytechnique, 1952) has been named sales representative for Roxalin of Canada Limited, Montreal.

T. Argyropoulas, JR.E.I.C.

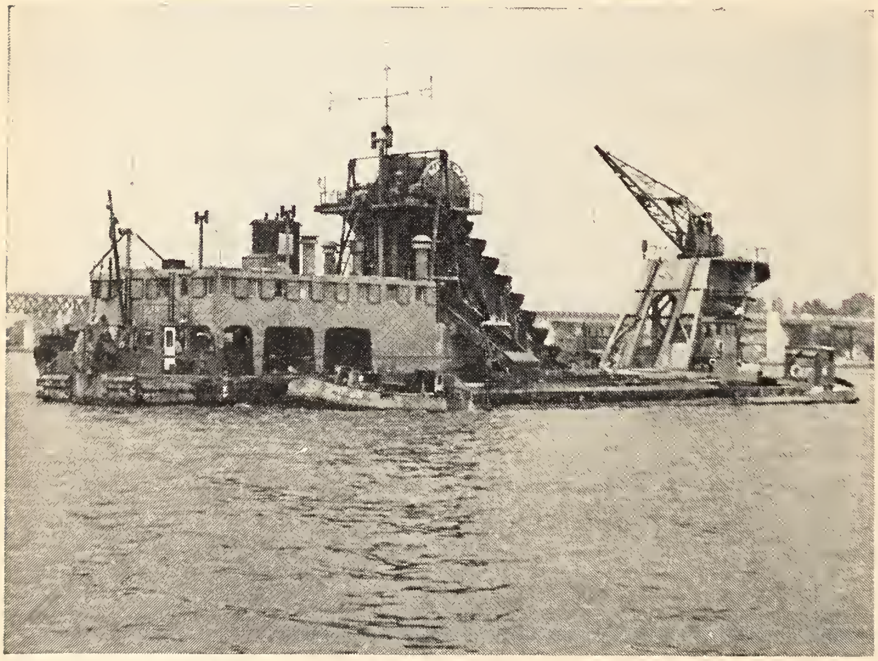
Joseph A. Baxter, JR.E.I.C.

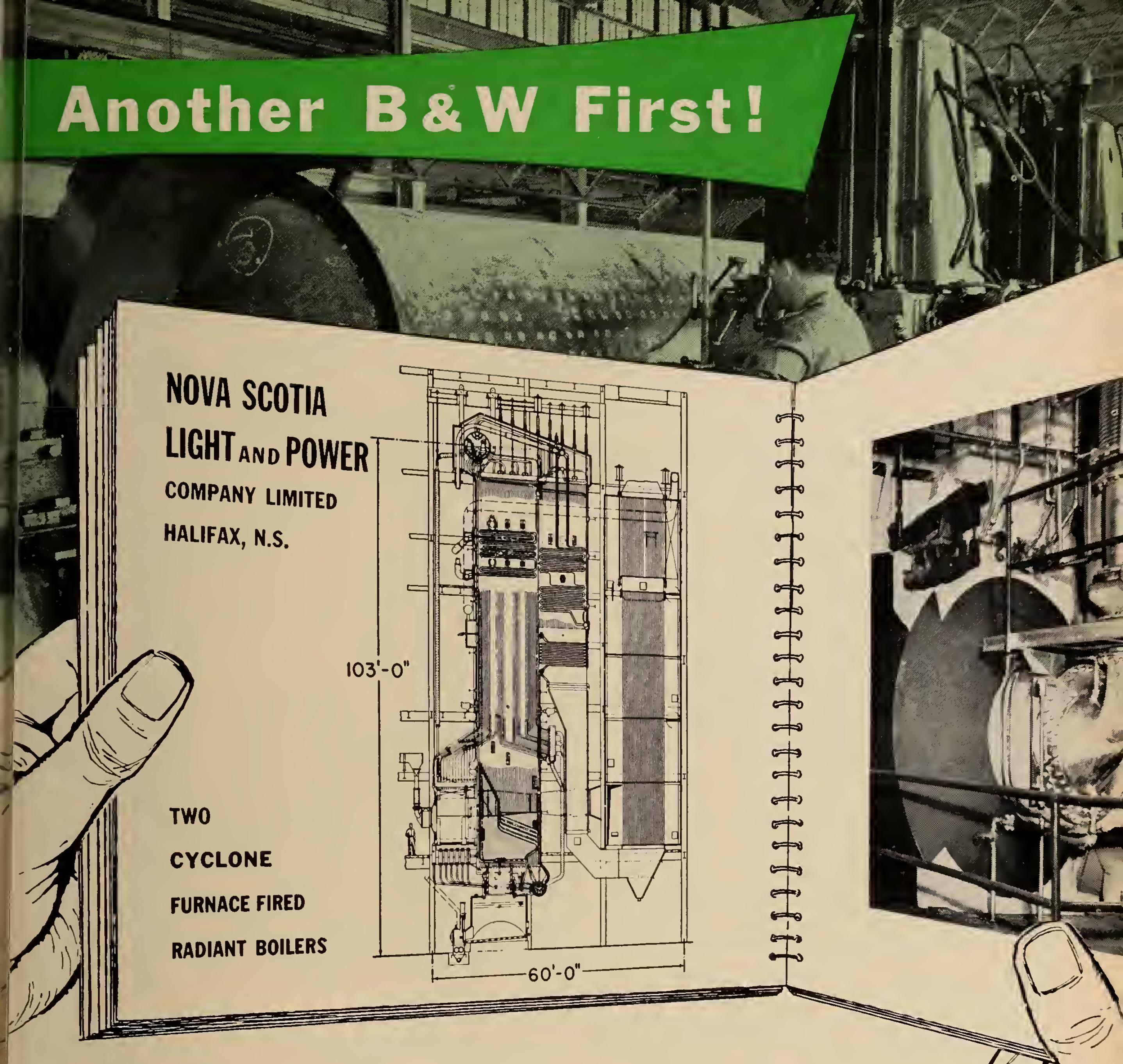
T. Argyropoulos, JR.E.I.C. (B. Eng., mech., McGill 1951) has joined Grumman Aircraft Engineering Corporation, Bethpage, New York, as systems analysis engineer.

David G. Turner, JR.E.I.C. (B.Sc., elec., Manitoba 1958) is a development engineer with the Defence Research Board, Canadian Armament Research and Development Establishment, Valcartier, Que.

Joseph A. Baxter, JR.E.I.C. (B.Sc., civil, New Brunswick 1957) has joined Gill and Company Limited, St. John, N.B., as sales engineer.

M. F. Pittuck, JR.E.I.C. (B.Eng., civil, McGill 1951) of Shawinigan Engineering Company Limited, Montreal, has





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BABCOCK-WILCOX AND GOLDIE-McCULLOCH LIMITED, GALT, ONTARIO MONTREAL • TORONTO • CALGARY • VANCOUVER been promoted to manager, planning, methods and cost control for the company.

D. Keith Marshall, JR.E.I.C. (B.Sc., civil, New Brunswick, 1952) is with Atomic Energy of Canada Limited, Chalk River, Ont.

R. W. Pigott, JR.E.I.C. (B.A.Sc., civil, Toronto 1957) is assistant construction engineer in the roads department, City of Ottawa.

G. V. Novotny, JR.E.I.C. (B.Eng., elec., McGill 1955) of Canadian Industries Limited, has been appointed project engineer, ammunition division, at the Brownsburg works.

Alfred Lapointe, JR.E.I.C. (B.Eng., elec., McGill 1957) is engaged in new construction and development with the Royal Canadian Navy at National Defence Headquarters, Ottawa.

E. Rohatynski, JR.E.I.C. (B.Sc., civil, Manitoba 1950) has been appointed assistant maintenance superintendent, smelter maintenance, engineering division of The Consolidated Mining and Smelting Company, Trail, B.C.

C. H. Albright, JR.E.I.C. (B.Sc., mech., Manitoba 1950) has been appointed maintenance superintendent, engineering services in the engineering division of The Consolidated Mining and Smelting Company, Trail, B.C.

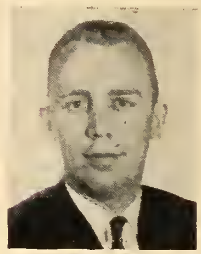
R. H. Reynolds, JR.E.I.C. (B.Sc., elec., Alberta 1951) has been named Company representative in Vancouver for Babcock-Wilcox and Goldie-McCulloch Limited.

R. H. Reynolds, JR.E.I.C.

M. F. Pittuck, JR.E.I.C.

G. C. Bellamy, JR. E.I.C. (B.Sc., mech., Queen's 1956) industrial sales representative for Imperial Oil Limited, has been transferred from North Bay, Ont., to London, Ont.

Terence Wm. Algeo, JR.E.I.C. (B.Sc., elec., Manitoba, 1950) has been appointed manager, Deutz engine sales, with Pritchard Engineering Co. Ltd., Winnipeg.



G. C. Bellamy, JR.E.I.C.

Terence W. Algeo, JR.E.I.C.

G. E. James Blaiklock, JR.E.I.C. (B.A.Sc., mech., Toronto 1951) of Foundation Maritime Limited, has been transferred to the Halifax office as executive assistant.

J. L. Carveth, JR.E.I.C., (B.Sc., mech., Alberta 1950; M.Sc., 1953) is a process engineer with Stearns-Roger Engineering Co. Ltd., Calgary, Alta.

Donald J. Kawaja, JR.E.I.C. (B.Eng., elec., N.S.T.C. 1956) design and switchgear engineer with Canadian General Electric Company Ltd., is on leave of absence for one year, and has taken on the duties of professor of engineering, St. Dunstan's University, Charlottetown, P.E.I.

D. L. Ginerick, JR.E.I.C., (B.Sc., mech., Saskatchewan 1954) of the Tidewater Oil Company, has been transferred from Regina to Shaunavon, Sask., as district engineer.

Gerard S. Sugiyama, JR.E.I.C. (B.Sc., mech., Manitoba 1949) has recently opened his own consulting engineering office in Winnipeg, Man.

George K. Fleming, JR.E.I.C., (B.Eng., mech., N.S.T.C. 1957) is working towards a masters' degree in applied science at the University of British Columbia, Van-

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couver. He is also instructing in the mechanical engineering laboratories.

A. L. Eisenhauer, JR.E.I.C. (B.Eng., mech., N.S.T.C. 1951) has joined Power-Gas Canada Limited, Montreal, as sales engineer.

I. B. Miller, JR.E.I.C. (B.Sc., elec., Queen's 1948) of English Electric Co. of Canada, has been transferred to the Toronto office.

Edward W. Thorne, JR.E.I.C. (mech., National Certificate, England 1954) is employed as estimating engineer with the Dundas Plumbing and Heating Co. Ltd., London, Ont.

Morris A. Bohn, JR.E.I.C. (B.Sc., civil, Queen's 1957) is a research assistant in the department of civil engineering at the University of Illinois.

Charles F. Lund, JR.E.I.C. (B.Eng., mech., N.S.T.C. 1950) has recently been appointed a section engineer with Canadian Celanese Limited, Drummondville, Que.

D. W. Turney, S.E.I.C. (B.A.Sc., engineering & business, Toronto 1958) is proceeding towards a master of commerce degree at the University of Toronto, while also being a part-time instructor in engineering drawing.

B. H. E. Maynard, S.E.I.C. (B.A.Sc., engineering & business, Toronto 1958) is starting his careeer with the Department of Defence Production, Ottawa.

F. W. A. Mosienko, S.E.I.C. (B.Eng., civil, Saskatchewan 1957) is employed with the Geodetic Survey of Canada, Ottawa.

R. W. Kyle, S.E.I.C. (B.Sc., civil, Saskatchewan 1958) is an engineer with the legal division of the Department of Mines and Technical Surveys, Ottawa.

F. Maisonneuve, S.E.I.C. (B.Eng., mech., McGill 1958 has joined Gypsum Lime & Alabastine, Montreal as plant engineer.

A. V. Widholm, S.E.I.C.

Lt. R. J. L. Rogers, S.E.I.C.

Lt. R. J. L. Rogers, S.E.I.C. (B.A.Sc., civil, British Columbia 1958) has joined the United Nations Emergency Force engineer company in the Middle East.

S. Sarsito, S.E.I.C. (B.Eng., civil., Nova Scotia Technical College 1958) is a highway engineer with the Ministry of Public Works, in Djakarta, Indonesia.

A. V. Widholm, S.E.I.C. (B.Sc., civil, Alberta 1957) is studying for a B.D. degree in preparation for foreign missionary service. He has been employed as field engineer for Haddin, Davis, & Brown Ltd., Edmonton, Alta.

R. Fancott, S.E.I.C. (B.Eng., mech., McGill 1957) is spending his second year of an Athlone Fellowship with Ewbank & Partners in London, England.

Joseph Ziegler, S.E.I.C.

Lionel R. Simard, S.E.I.C.

Joseph Ziegler, S.E.I.C. (B.A.Sc., mech., British Columbia 1958) is in Salt Lake City, Utah, where he is employed as a design engineer.

Lionel R. Simard, S.E.I.C. (B.Eng., civil, Polytechnique 1958) is city engineer with the City of St. Lambert, Que.

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NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute and abstracts of the papers presented at their meetings

BAIE COMEAU

G. W. Scott, M.E.I.C. *Correspondent*

Herbert J. Racey, exec. vice-president of Racey, MacCallum and Associates Limited, Montreal, was the speaker booked for the meeting of February 4. Neill Holloway of the engineering staff of Racey, McCallum substituted for him, giving the paper on Lessons Learned from Structural Failures.

Five cases were discussed: three of concrete structures which had failed because of insufficient protection from freezing in cold weather operations, and two of structural steel failures caused by a lack of provision for the resistance of lateral forces.

BELLEVILLE

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

R. L. Beck, M.E.I.C., application engineer of C.G.E., Peterborough, was the speaker on March 9. Progress in Atomic Energy was his subject.

The interesting talk, illustrated with slides, reported the application, requirements and economics of nuclear plants for the production of electric power, process steam and combined power and heat.

The fission cycle, thermal cycle, and the physical layout of atomic plants were discussed, and also the different British, American and Canadian approaches to nuclear power. There was a lively discussion period, indicating great interest.

BORDER CITIES

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

Assumption University was the location and the subject of a panel discussion on January 15, 1959. In the university library, three speakers discussed the history, present standing and future plans of the newly formed university. They were: F. A. DeMarco, chairman of the staff of Essex College; W. H. Arison, chairman of the board of Essex College; and C. T. Carson, chairman of the Engineering Educational Committee.

The Ladies Auxiliary has a membership of 81, and an average attendance of 40 at meetings. The group celebrated their seventh anniversary at the annual dinner meeting this year. New officers elected are Mrs. C. M. Armstrong, president; Mrs. H. V. Chapman and Mrs. J. W. Brison, vice-presidents; Mrs. J. E. Sennot, recording secretary; Mrs. E. T. Rivington, corresponding secretary; Mrs. L. T. Raham, treasurer; Mrs. R. H. Darke, group convenor; Mrs. D. Servage, publicity; Mrs. J. D. Livingstone, Mrs. J. E. Dykeman and Mrs. J. M. Reid, councillors.

Four interest-groups are promoting friendship among the members. Seven general meetings were held during the past year.

Mrs. J. W. Brisson, Mrs. C. M. Armstrong, and Mrs. H. J. Chapman, of the Border Cities Branch Ladies Auxiliary.

EDMONTON

I. G. Finlay, M.E.I.C., *Correspondent*

A joint meeting was held by the Edmonton Branch and the Engineering Students Society, University of Alberta, on January 13. A film on the demolition of Ripple Rock was presented, by courtesy of the Federal Department of Public Works, to an audience of about 200.

The annual joint dinner meeting with the Association of Professional Engineers of Alberta was held on January 23. There were 200 present.

PRESIDENT K. F. Tupper visited the Corner Brook Branch (left) on February 16, the Northern New Brunswick Branch (below) on February 9, and the Halifax Branch (below, left) on February 12. He was accompanied by General Secretary Garnet T. Page. The pictures show:

***Corner Brook:* Mrs. Garnet Page, K. F. St. George, Mrs. Leja, Dr. Tupper, E. A. Leja, Mrs. Tupper.**

***Halifax:* Dr. I. P. Macnab, Dr. Tupper, W. J. Phillips, G. F. Vail, R. D. T. Wickwire; *Northern N.B.:* T. H. McSorley, W. S. Hosking, S. K. Henry, Dr. Tupper, D. C. McCallum, P. Dallien, L. L. Marshall.**

• BRANCH NEWS

FREDERICTON

Lyle W. Smith, JR.E.I.C., *Correspondent*

DR. K. F. TUPPER, E.I.C. president, visiting the branch on February 18, spoke about his Russian tour of last October.

Dr. Tupper was accompanied by Mrs. Tupper, and by General Secretary Garnet T. Page and Mrs. Page.

Welcoming the guests to New Brunswick were: Premier Hugh John Flemming, Public Works Minister J. Stewart Brooks, and Mayor William T. Walker.

Other items of interest announced were: award of life membership to S. W. Babbitt; E.I.C. award to fifth-year engineering student Mr. Gallant; and presentation of Athlone Fellowship to D. Hayward.

NOVA SCOTIA TECHNICAL COLLEGE

John Jay, S.E.I.C., *Correspondent*

THE ANNUAL TECH BALL, was held in Halifax and the exhibits, centering around a "space travel" theme, were judged by prominent engineers and their wives. For the first time, this year, a cup was presented by the Engineering Institute of Canada to the department displaying the best exhibit. J. D. Kline, past chairman of the Branch, presented the trophy to the winning civil engineering department. Their model of a domed city expressed their idea of a city for another planet. Other exhibits included models of rockets, space stations, and space costumes.

SUDBURY

Fred Jackson, M.E.I.C., *Correspondent*

MODERN ELECTRICAL CONTROL IN THE MINING INDUSTRY was discussed by Eric Oldfield, of Canadian Westinghouse Ltd., at a meeting on March 12, 1959. Means of electrical control of mining and reduction equipment were reported.

NIPISSING AND UPPER OTTAWA

D. J. Thornton, S.E.I.C., *Correspondent*

J. W. "WES" MCNUTT discussed the Russian Lumber industry, and the role of the engineer, at a meeting on January 14. He is the president of Wm. Milne Ltd., and Moose Lake Lumber Co., North Bay. His talk was based on a three week visit to Russia in 1956.

Nipissing and Upper Ottawa Branch, front, R. Prescott, Chairman J. S. Cooper, J. Warburton; back, G. M. Goodreid, R. S. MacLennan, P. Rebin, J. Rosborough.

PLASTIC PIPING FOR INDUSTRIAL PURPOSES was discussed by J. E. McEwen, M.E.I.C., on February 11. This monthly dinner meeting was held at Temiskaming, Que. Mr. McEwen is in the plastics division, of Rahn Metals Limited, North Bay, Ont.

He described some of the thermal molding operations by which resin becomes the finished product: e.g. setting, injection, or extrusion molding. Properties of polyethylene, polyvinylchloride and nylon were discussed and of the newly developed polypropylene, which seems to have unlimited possibilities. Uses and applications of plastic piping were demonstrated.

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• BRANCH NEWS

EASTERN TOWNSHIPS

Jean Bourassa, JR.E.I.C., *Correspondent*

EXIT AND RE-ENTRY PROBLEMS OF MISSILES AND ROCKETS were presented by Dr. G. B. Bull at a meeting of February 20, 1959. Dr. Bull is superintendent, aerophysics wing, Canadian Armament Research and Development Establishment, Valcartier, Que.

The speaker told of the problems encountered in aerophysics and of the Canadian research and achievements, from the first experiments at Baddeck, fifty years ago. The modest wind tunnel at the University of Toronto in the 1920's was described. There was also illustration and details of experimental work being done at CARDE on test models propelled in tunnels simulating space flights at very high speed.

At the Eastern Townships Branch meeting of February 20: Geo. M. Dick, Councillor Ben Baker, speaker G. B. Bull, Chairman G. P. Cote, and E. T. Webster.

SASKATOON SECTION

Roger Dupuis, M.E.I.C., *Correspondent*

STUDENTS PAPER NIGHT was attended by 31 students and 14 members. The Student Section was very successful in all phases of the arrangements.

Adjudication was in the hands of Dr. F. H. Edmunds, Department of Geology, University of Saskatchewan. After hearing four well prepared and ably delivered papers, he chose two winners, with wholehearted approval of the meeting: first, R. E. George; second, J. B. Franklin.

Their subjects were, respectively, "Run-in of Journal Bearings with Various Lubricants", and "Feasibility of Direct Current Transmission Lines".

UNIVERSITY OF NEW BRUNSWICK

Hans Foerstel, S.E.I.C., *Correspondent*

ENGINEERING WEEK the week of January 17-23, had these main events:

Wassail Dinner: traditionally, faculty members, president of U.N.B., chairman of E.I.C. Branch told their stories and jokes;

Social night: engineers entertain gals.

Hockey game: Foresters vs. engineers, with heavy losses, engineers won, 5-4.

Film night: Movies on the new Fredericton bridge, with comments by E. Donohoe of Intrusion Prepakt Co. Ltd.

Engineering Formal: apex of the week, well-attended; excellent music, crowning of the engineering queen.

PORT HOPE

D. A. Runciman, JR.E.I.C., *Correspondent*

HIGHWAY PLANNING AND URBAN TRAFFIC PROBLEMS were discussed by A. J. Freedman, municipal studies engineering, Dept. of Highways, at a meeting on February 11, 1959.

Factors to be considered in planning

• BRANCH NEWS

a new, or improving an existing road are: population density of the area; land use near the route, expected traffic density on the proposed road, and many others.

SAINT JOHN

H. K. Larsen JR.E.I.C., *Correspondent*

PRESIDENT K. F. TUPPER, president of the Institute, visited Saint John on February 19, accompanied by Dr. Garnet T. Page, general secretary. They were luncheon guests of the executive. They also attended a branch dinner, with Mrs. Tupper and Mrs. Page, at which members had the opportunity of hearing Dr. Tupper speak on the Institute's international affiliations and on his recent trip to the U.S.S.R. with Dr. Page.

SASKATOON, Ladies Auxiliary

Mrs. W. G. McKay, *Correspondent*

A NEW WOMEN'S GROUP was organized in Saskatoon: The Professional Engineers' Wives Club of Saskatoon.

Mrs. J. B. Mantle and Mrs. E. J. Cole were in charge of an organizational meeting at Clinton Lodge attended by about 50 members. A constitution was set up and the first executive was elected.

Honorary president is Mrs. Mantle. Mrs. H. McI. Weir was chosen as president; other officers are: vice-presidents, Mrs. E. Kent Phillips, Mrs. A. E. Beazely; secretary, Mrs. W. G. McKay, treasurer, Mrs. J. G. Trotter; convenors, Mrs. R. C. Strayer and Mrs. F. A. Gerard. Another meeting was announced for March 3.

SAULT STE. MARIE

R. L. Wimperis, JR.E.I.C., *Correspondent*

"A GIFT OF NATURE", a picturesque but non-technical film on hydro development in Ontario, was shown at a meeting on January 30. The film covers hydro developments historically, including some interesting film taken during the actual building of the earlier projects.

PROFESSOR E. KEMP, Professor of mining and geology, Michigan School of Mining and Technology, Sault Ste. Marie, Mich., was the speaker on February 26; his subject: Geologic Time.

Geologic time is figured by such methods as the rate of decay of Uranium or Carbon 14 in the bodies of old animals and plants. By this scale the earth was formed approximately 10,000 years ago.

TORONTO

G. Norton, JR.E.I.C., *Correspondent*

THE FUTURE OF METALS was the subject discussed by Dr. L. M. Pidgeon on December 11, 1958. Dr. Pidgeon is head of the department of metallurgical engineering, University of Toronto.

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He divided the 16 most abundant metals into four groups—precious, classical non-ferrous, modern non-ferrous, manufactured metals. He discussed each group in terms of the required capital structure, the complexity of the metallurgy, the marketing problems and the ratio of production cost to selling price. It was said to be possible that aluminum, iron, magnesium and titanium will prove to be the most widely used metals, particularly in view of the advent of atomic energy.

Dr. A. I. Johnson, Associate Professor, Department of Chemical Engineering, University of Toronto, spoke at the meeting of February 19, 1959. His subject was High Speed Photography in Chemical Engineering.

To illustrate the problem of observing phenomena, Dr. Johnson outlined some typical speeds: 22 ft/sec. for the four minute mile; 100 ft/sec. for a 70 m.p.h. train; and 3000 ft/sec. for a bullet. The phenomena which he was studying were in the order of 100 ft. per sec. in one case, and once every 1/300 of a second, in another.

Camera speeds vary from 16 to 6,000 frames per second. Time magnification results when high speed movies are shown at sixteen frames per second. For instance, pictures taken at 6,000 frames per second require 150 seconds of viewing for each second of exposure. Usefulness of the technique was demonstrated by pictures of circulation patterns in drops, formation of air bubbles, air atomization of liquids, nucleate boiling from a hot wire, and mixing of liquids.

UNIVERSITY OF ALBERTA

Elections of Officers for 1959-60 resulted in the following list of officers: President, Jim Ford; vice-president, Dennis Lindberg; second vice-president, Bob McKenzie; Secretary, Elgie McGrath; Treasurer, Rae Donald, social convener, Ron Bullen; sports director, Ray Speer.

WINNIPEG

P. M. Abel, jr.e.i.c., *Correspondent*

The Brandon Generating Station, its design, construction and operation was discussed and illustrated by four speakers from the Manitoba Hydro-Electric Board, on February 19, 1959. They were: A. W. Knight, engineer, J. Karras, engineer, J. Shipper, electrical constructional engineer, and S. C. Irving, superintendent; introduced by J. R. Rettie, manager, engineering and construction division.

The discussion included a general review of the civil, mechanical, electrical, and operating features incorporated into the Brandon generating station. This is a steam turbine station of 132,000 kw. capacity, recently completed and placed into operation by The Manitoba Hydro-Electric Board.

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 in February 1959.

Member: B. B. Babicki, Vancouver; R. Farrand, St. Johns, Que.; J. W. J. Lewis, Winnipeg; A. C. McDonald, Sarnia; O. G. Moffat, Hamilton; H. W. Moxon, Peterborough; R. J. Oliver, Ottawa; A. G. Patil, Montoursville, Penn.; G. L. Ray, Calgary; M. W. Shishakly, Montreal; T. R. B. Watson, Toronto.

Junior: G. A. Escher, Montreal; M. A. Fraser, Montreal; A. Galatis, Montreal; A. A. Palajs, Montreal; M. V. Price, Montreal; R. C. Stutchburg, Baie Comeau.

Affiliate: H. F. Neuman, Calgary.

Member: J. A. M. Bell, Montreal; R. T. Crawford, Calgary; L. Griffith, Texas.

Junior: B. H. L. Tache, La Prairie.

STUDENTS ADMITTED

University of Toronto: C. Alexopoulos; A. J. Barone; D. H. Blenkarn; R. M. Bodrug; P. I. P. Boulton; F. G. Bowyer; J. H. E. Cracknell; B. A. Didyk; J. M. Farley; R. D. Foster; G. D. Gamsby; H. M. Goodfellow; B. C. Gregory; R. E. Howard; R. R. Hudgins; W. P. Inksetter; W. F. Johnson; E. Kovacs; D. K. Laine; J. T. Lawrence; D. J. Morton; M. L. Pearson; M. G. Quaid; E. W. M. Rankin; J. B. Ridpath; D. C. Robinson; A. C. Shaw; L. W. Sobczak; T. H. Topper; W. S. Wei; I. M. Wilson.

University of New Brunswick: D. W. Bates; W. H. Batt; W. W. Beairsto; P. S. Belyea; L. G. Blight; K. T. Brodersen; D. Bryant; L. J. E. Byer; D. C. Champion; W. F. Cunningham; G. B. Ducharme; M. A. Dunphy; A. B. Estabrook; D. A. Lutes; R. D. Mongtomery; I. Nemet; K. B. Porter; E. C. Read; B. O. Sauer; H. W. Shephard; E. E. Sherrard; L. C. Sherwood; G. D. Stevens; L. O. Taylor; L. S. Wilson.

University of Western Ontario: G. W. Bailey; K. B. Bie; L. J. Budden; J. G. Duncan; M. E. Fraser; J. E. Gardner; R. A. Grace; J. K. Holmes; M. F. James; H. N. Kagawa; S. J. Palka; G. N. Steels; J. Westeinde; F. R. Wiesegger; G. R. Wilmott.

Canadian Services College: R. H. Crane; A. T. Downs; L. A. Gibbon; R. J. Kovacs; S. A. Money; S. C. Shepherd; D. C. Smith; M. B. Sullivan.

St. Joseph's University: E. D. Boudreau; P. A. Comeau; P. A. Dysart; P. Gaudet; C. Levesque.

McMaster University: J. L. Antikian; J. Van Arragon; G. A. Roeder; D. H. Smith.

University of Sherbrooke: G. Lallier; C. Lauzier; B. Letourneau; J. R. G. Pelletier.

St. Francis Xavier University: K. L. Chisholm; L. J. Torok.

University of British Columbia: K. Dau.

University of Alberta: R. P. Parish.

Massachusetts Institute of Technology: V. Mashaal.

Sir George Williams College: T. Katz.

Queen's University: L. G. Smith.

A.P.E.O.: J. R. Grant.

Applications Through Associations

By virtue of the co-operative agreement between the Institute and the Associations the following elections and transfers have become effective.

ALBERTA

Members: A. Bellingham; W. R. Campbell; F. E. Deakin; R. R. Gregory; L. S. Szabo.

Junior: H. Quintilio.

SASKATCHEWAN

Member: G. S. Sanders.

E.I.C. ANNUAL MEETING, 1959

TORONTO, JUNE 8, 9, 10

LIBRARY NOTES

ADDITIONS TO THE INSTITUTE LIBRARY • REVIEWS • BOOK NOTES • STANDARDS

BOOK 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 ELEVATED TEMPERATURE STRAIN GAGES

Fourteen papers and a panel discussion covering various types of strain gages, including resistance wire, metal-film, foil, and optical; gage alloys, bonding agents; and temperature compensation techniques. The symposium was sponsored by the Aeronautical Structures Laboratory, Naval Air Material Center in 1957. (Philadelphia, American Society for Testing Materials, 1958. (s.t.p. no. 230.) 163p., $4.50.)

GEOLOGICAL STRUCTURES AND MAPS, 2ND ED.

In this enlarged edition, material has been included which will be particularly useful to civil and mining engineers. The first section of the book consists of a survey of the principles of interpretation of geological maps, including sedimentary rocks; outcrops; folds; faults; erosion; igneous beds; drift deposits; oil bearing structures; borehole and shaft sections; location of concealed coalfields and planning the development of mine workings. The second section contains maps and exercises based on the text. (A. Roberts. London, Cleaver-Hume, 1958. 92p., 12/6.)

*PUNCHED CARDS: THEIR APPLICATIONS TO SCIENCE AND INDUSTRY, 2ND ED.

Beginning with an introduction to the use of a simple punched-card file, the book continues with case histories of punched-card applications including the Peek-a-Boo System, the Uniterm System, mechanized coding and searching techniques applied to the metallurgical literature, the Zato-coding System, and the use of punched-cards in linguistic analysis as applied to ancient texts such as the Dead Sea Scrolls. This is followed by fundamental considerations in coding and system design, future possibilities, and an annotated bibliography on the uses of punched-cards. (Ed. R. S. Casey and others. New York, Reinhold, 1958. 697p., $15.00.)

FUNDAMENTALS OF PIPE DRAFTING

Intended for drafting students with a basic knowledge of mechanical drawing who wish to develop skill in pipe drafting. It covers piping symbols and their representation; diagram drawing; controls; pipe and pipe fittings; specification of parts; detail drawing. The text includes problems and a glossary of piping terms. (C. H. Thompson. New York, Wiley, 1958. 66p., $3.50.)

GROUNDS MAINTENANCE HANDBOOK

This volume covers all aspects of maintenance from the selection of land to the methods necessary to keep the area in first class condition. It covers planning; the growth and maintenance of turf; planting and care of trees, shrubs and perennials; equipment maintenance and use; disease, insect and weed control; soil erosion; roads and parking areas; materials specifications; maintenance of picnic areas. The author is now a landscape artist with the Power Authority of the State of New York on the St. Lawrence Power Project. (H. S. Conover. New York, Dodge, 1958. 501p., $10.75.)

GENERAL THEORY OF ELECTRICAL MACHINES

Based on a graduate course given at Imperial College, this volume presents a general theory applicable to all types of electrical machines. The subjects covered include methods of analysis of machines; d.c. and a.c. machines; d.c. machines in control systems; a.c. operation of synchronous and induction machines; methods for generator and system analysis; the generalized rotating machine. A chronological bibliography covering the years 1923 to 1954 is included. (Bernard Adkins. Toronto, Ryerson, 1957. 236p., $9.00.)

WHO'S WHO IN WORLD AVIATION AND ASTRONAUTICS, 1958

There are over 3000 biographies in this second edition of a useful directory, which, in spite of its title, is concerned mainly with residents of the United States. The persons included are officials of aircraft, engine and associated industries, scientists, air force officers, government officials and others who have taken an interest in or contributed to aviation, astronautics and allied fields. (Ed. by M. E. Grambow. Washington, American Aviation Pubs., 1958. 497p.)

AGREGATS LIANTS ET BETONS HYDRAULIQUES, ACIERS ET METAUX USUELS

The first section of this volume deals with various kinds of aggregates for hydraulic concrete, hydrocarbon concrete, and concrete used for roads. The second section considers limes and cements used in construction, with standards for their manufacture and use. Mortars and hydraulic concrete are discussed in the third chapter, and steel and other metal used in construction in the last. The book contains a great deal of very detailed information. (J. Arrambide and M. Duriez. Paris, Editions du Moniteur des Travaux publics, 1958. 596p., 2475 fr.)

TABLES ABREGEES DE PUISSANCES ENTIERES

Tables prepared especially for use with calculating machines, giving whole powers of numbers higher than cube. These powers are given in the tables to ten, and sometimes to fifteen significant figures. The author explains the method by which the tables have been calculated in his introduction, and also explains their use. The tables have been printed

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THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these Notes are now available in the Library. Members of the Institute may borrow books, periodicals, pamphlets, etc. from the Library. The loan period is two weeks, excluding time in transit, and two items may be borrowed at one time. Library hours are: Monday to Friday: 9 a.m.—5 p.m.; Saturday: 9 a.m.—12 noon.

Because of a recent change in policy, publications (except periodicals published by other engineering societies) may no longer be purchased through the Library. If members have difficulty obtaining material locally, it is suggested they write to the Library, and the enquiry will be forwarded to an appropriate bookseller. For further information write to the Librarian.

by photographing the original handwritten sheets, to avoid error in composition. (P. Montagne. Paris, Dunod, 1958. 411p., 5,600 fr.)

PRECIS D'ELECTROTECHNIQUE A L'USAGE DES INGENIEURS

Translated from the English edition, Basic Electrotechnics, this volume is intended as a text for electrical engineering students, and covers basic electromagnetic theory. The topics dealt with include steady and alternating current theory, electrostatic fields, condensers and dielectrics, electrodynamics, the calculation of magnetic fields, Maxwell's equations and electromagnetic waves, generators and other apparatus. (B. L. Goodlet. Paris, Dunod, 1958. 354p., 3300 fr.)

CIRCUITS A RELAIS ET AUTOMATISMES A SEQUENCES

In this volume the author presents methods for the analysis and synthesis of relay circuits in calculating machines. The first three chapters contain a general survey of the subject, the operation of the machines, some examples of circuits, and an outline of coding and programming. The remaining chapters consider in more detail the two fundamental problems connected with this subject, the systematic simplification of logical functions and the establishing of contacts to satisfy a given system of logical equations. (P. Naslin. Paris, Dunod, 1958. 240p., 2700 fr.)

MESURES EN RADIOTECHNIQUE

Intended as a handbook for students, to bridge the gap between theoretical courses and actual practical applications, this text tries to give general principles rather than actual experiments. The eleven chapters cover: general characteristics of materials and of measuring instruments; circuits; low, and very high high frequency measurement; vacuum tubes; high frequency impedance measurement of radioelectric frequencies; transmitters; electromagnetic fields; receivers. (E. Fromy. Paris, Dunod, 1958. 784p., 9800 fr.)

*SCIENTIFIC USES OF EARTH SATELLITES, 2ND ED.

The present edition has been enlarged to the extent of almost being a handbook of earth satellites. Those areas most extensively revised are the orbit of a small earth satellite, insolation of the upper atmosphere and of a satellite, meteorological measurements and measurements of the earth's magnetic field from a satellite vehicle, ionospheric structure as determined by a minimal artificial satellite, and measurements of interplanetary dust. (Ed. by J. A. Van Allen. Toronto, Ambassador, 1958. 316p., $13.50.)

UNFIRED PRESSURE VESSEL CODE SIMPLIFIED

This latest edition is based on the A.S.M.E. Code and contains simplified charts for internal and external pressure; shell thickness, flanged and dished head thickness, flat head thickness, flat cover plate thickness and openings and reinforcements, external pressure on heads, stamping, head and shell volumes, welding qualification positions, new information on magnetic particle and penetrating oil tests, plate identification, nonidentified material, articles on Canadian pressure vessel requirements, the Code symbol and certificate procedure to follow to obtain them, and welded repair procedure. (R. Chuse. Leonia, N.J., 1958. 48p., $6.50.)

RADIO COMMUNICATION

The fundamentals of radio communication theory are presented in this text which is written at the undergraduate level. Some of the topics covered include: circuits; transformers; sound reproduction; radio transmission and reception; feedback; amplifiers; oscillators; modulation; radio waves; transistor amplifiers, etc. The book is written from the viewpoint of the engineer rather than the mathematician. (W. F. Lovering. Toronto, Longmans Green, 1958. 536p., $10.80.)

ELECTRONIC DIGITAL COMPUTERS: THEIR USE IN SCIENCE AND ENGINEERING

The emphasis in this volume is on the operation rather than the design of computers, and the capabilities and uses of the various types of machines are discussed. The author first considers functions, components, number representation, memory, input and output. Other chapters cover coding and programming, problem analysis and machine operation. There is a useful bibliography. (F. L. Alt. New York, Academic, 1958. 336p., $10.00.)

UPLIFT IN GRAVITY DAMS

The author's first publication on the subject of uplift was a letter which appeared in Nature in January 1942. He has since published several papers and reports, and this volume presents his latest theories. The first two chapters discuss the different theories which have been advanced for the calculation of the pressure of water infiltrating through the material of a gravity dam. In the third chapter, the various experimental approaches to the problem are considered, and the problems associated with these. The final chapter discusses the methods of reducing uplift pressure and leakage in dams by providing a waterproof screen. (Serge Leliavsky. Toronto, Longmans Green, 1958. 267p., $9.00.)

*THOMAS TELFORD

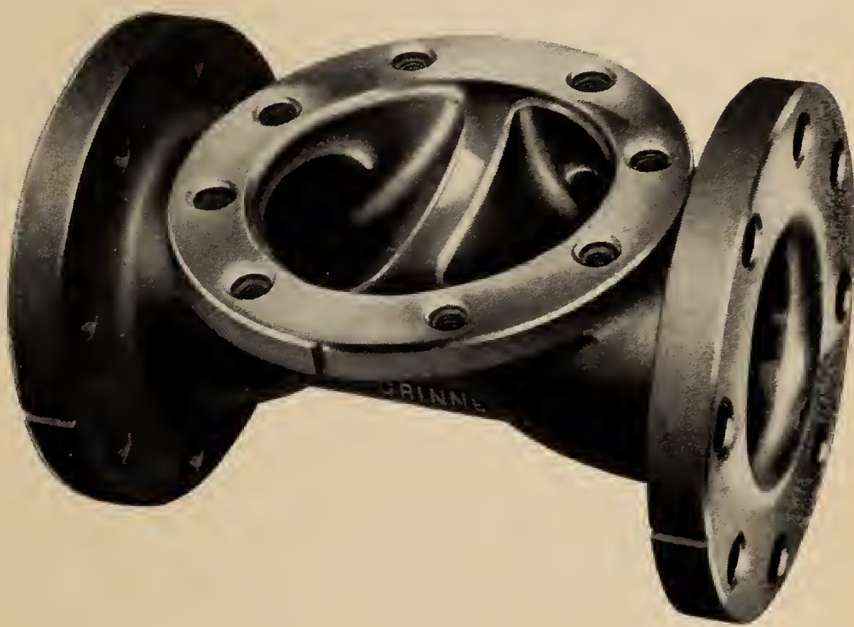
The story of a great Scots engineer who built bridges, roads, aqueducts, and canals. The author has written a more detailed account than has hitherto been available, and at the same time has tried to present a portrait of Telford as a man. In addition to his great engineering feats, Telford served as first president of the Institution of Civil Engineers, and occupies a significant place in the history of engineering. (L. T. C. Rolt. Toronto, Longmans Green, 1958. 211p., $5.00.)

*AXIAL FLOW COMPRESSORS

Beginning with a brief review of basic fluid dynamics and thermodynamics, the book continues with a discussion of two

Now... you can have Grinnell-Saunders* Diaphragm Valves of

Ductile Iron with Glass-Lined Bodies



Saunders — Reg. Trade-mark

After long research, Grinnell has available top quality, corrosion-resistant glass lined bodies for its line of rugged ductile iron valves.

EXTRA TOUGHNESS The greater toughness of ductile iron resists impact, torsion, line strains and thermal shock. Grinnell-Saunders valves of ductile iron handle severe service requirements where both internal and external impact shocks may be expected, and where piping stresses from rapid heating and cooling occur.

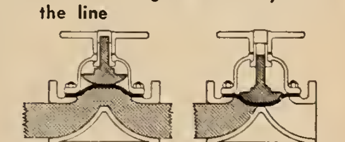
ECONOMY Approved and used by leading industries, ductile iron offers many of the benefits of cast steel at a lower price.

Of particular importance to users of Grinnell-Saunders valves is that ductile iron bodies can now be *glass-lined*—a procedure not practical with cast steel bodies.

WIDE SELECTION Body linings: glass, rubber, neoprene. Diaphragms: soft natural rubber, natural rubber, white synthetic rubber, neoprene, reinforced neoprene, butyl, Hycar, Teflon, Kel-F, PVC (polyvinyl chloride), polyethylene. Bonnet materials: ductile iron, grey iron. Bonnet styles: handwheel (non-indicating stem or indicating stem), chain wheel, lever for quick operation, and sliding stem for a wide selection of power operated topworks.

Important features of the Grinnell-Saunders Diaphragm Valve

- Diaphragm completely isolates operating mechanism from the fluid in the line
- Diaphragm lifts high for full, streamline flow in either direction
- Diaphragm effects positive, leak-tight closure
- Diaphragm easily replaced without removing valve body from the line



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GRINNELL-SAUNDERS DIAPHRAGM VALVES

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pipe fittings • welding fittings • pipe hangers • valves • Grinnell-Saunders diaphragm valves • pipe prefabricated piping • heating specialties • water works supplies • Grinnell automatic fire protection systems dimensional cascades; pitch line design of compressor stages; calculation of losses, stage efficiencies, and characteristics; compressor testing and instrumentation; supersonic compressors. Extensive references are given. (J. H. Horlock. Toronto, Butterworth, 1958. 189p., $8.00.)

°SAMPLED-DATA CONTROL SYSTEMS

Discusses the basic theory of sampled-data control systems in particular and circuits, networks, computers, and system engineering in general. A general approach is provided to mixed digital-analog linear systems along with a thorough discussion of the z-transform method which can be applied to a wide variety of fields. Problems arising in feedback control systems are solved and discussed by means of application of digital computers. General applications of the z-transform method and the operational solution of linear difference equations are enumerated and clarified. (E. I. Jury. New York, Wiley, 1958. 453p., $16.00.)

PROCEEDINGS OF THE CONFERENCE ON THE PROPERTIES OF MATERIALS AT HIGH RATES OF STRAIN

This conference was held in London in 1957, under the auspices of the Institution of Mechanical Engineers. Twenty-two papers were presented on a subject which is becoming of increasing importance. The paper at the first session dealt with the deformation of solids at high rates of strain. The other sessions considered experimental techniques, metal working, impulse loading and stress waves, non-metallic materials, and basic properties of materials. (London, Institution of Mechanical Engineers, 1958. 268p., £3.3.0.)

°AMENAGEMENT, UTILIZATION ET PRIX DE REVIENT DES USINES HYDRAULIQUES

This book is the first volume of a treatise on hydraulic engineering. The first part deals with the general mechanics of hydraulic engineering, equipment, analyses of power systems, and the various aspects of electrical power. Then the integration of water power production into the total production of the country, and the problems of conservation of water supply are discussed. The last part deals with economic factors involved in the production and distribution of power. (H. Varlet. Paris, Eyrolles, 1958. 211p., 3,000 fr.)

°TOPICS IN ELECTROMAGNETIC THEORY

A unified treatment of topics in the field of electromagnetic theory and microwave electron tubes. The first chapter is devoted to periodic transmission systems and lays the groundwork for the following chapters which deal with propagation on a wire helix, concepts concerning coupling of modes of propagation, and anistropic media with particular reference to the ferrite. (D. A. Watkins. New York, Wiley, 1958. 118p., $6.50.)

°JUNCTION TRANSISTOR ELECTRONICS

An attempt to provide engineers with a co-ordinated source of information about the characteristics and circuit applications of transistors. The first half of the book deals with low frequency, linear applications and with background device physics and characteristics. The remainder of the book covers more general network analysis techniques, a greater variety of circuit applications, more complicated broadband and high-frequency circuits, and non-linear switching applications. Useful tables of transistor circuit formulas and a substantial number of numerical examples are included. (R. B. Hurley. New York, Wiley, 1958. 473p., $12.50.)

°INTRODUCTION TO THE THEORETICAL AND EXPERIMENTAL ANALYSIS OF STRESS AND STRAIN

An introduction to the field of stress analysis that covers the theory of elasticity, dimensional analysis, mechanical strain gages, brittle coatings, and grid methods. The theory of elasticity is presented from the general three-dimen-

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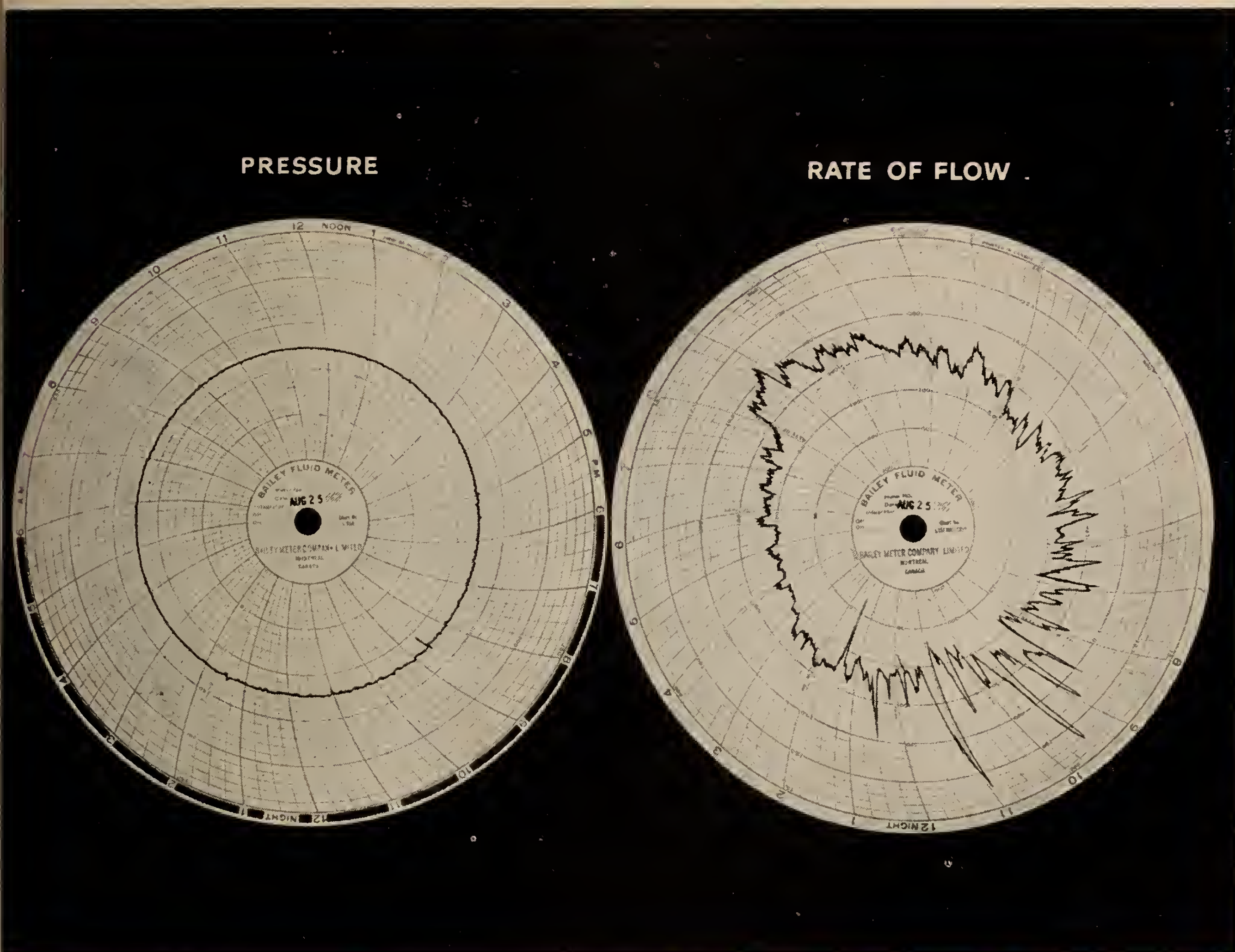
The Bailey Air Operated Control System, automatically regulates two 15,000,000 Imperial Gallon capacity, variable speed, high lift pumps each fitted with a hydraulic coupling . . .



Here are the Pressure and Rate of Flow records from one of these high lift pumps. Note what happened at 10.55 p.m. on August 25th . . . the flow increased 10.2 M.I.G.P.D. (67% of pump capacity) almost instantaneously, and there was a momentary drop in pressure of only 5 psi!

During the 24 hours when these charts were being recorded only one variable speed pump was in operation . . . and its output represented approximately 20% of the total plant output.

Every minute of every hour, Edmonton's water supply depends on BAILEY!

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ENGINEERS AT YOUR SERVICE FROM COAST TO COAST sional point of view, and although the conventional parallelopiped approach is used, a rigorous theoretical development is given where necessary. Technical detail has been de-emphasized in favor of basic concepts which are applied to the solution of specific problems. (A. J. Durelli and others. Toronto, McGraw-Hill, 1958. 498p., $15.00.)

TIMBER ENGINEERING DESIGN HANDBOOK

Written by three senior officers of the Timber Mechanics Laboratory of the C.S.I.R.O., this handbook is intended primarily for Australian engineers and architects, but will prove valuable to all those interested in timber construction. It covers the use of timber as a structural material; design loads; design stresses for solid timber; the design of beams, columns, joints and trusses; glued laminated construction; the structural use of plywood; proof testing and preservation. The final chapter gives examples of timber structures, both in Australia and elsewhere. (R. G. Pearson and others. Melbourne, University Press and Commonwealth Scientific and Industrial Research Organization, Toronto, Macmillan, 1958. 248p., $5.00.)

*SEWERAGE AND SEWAGE TREATMENT, 8TH ED.

The sewage project is covered from its inception to design, construction, operation, and maintenance. In this revised edition, new material on oxidation ponds has been included, and the attention to practice in sludge treatment and disposal has been increased. Additional information is also given on the subject of stress-pollution prevention and the oxygen-sag curve. A review of the literature since the last edition in 1952 is presented and approximately half the illustrations are new or revised. (H. E. Babbitt and E. R. Baumann. New York, Wiley, 1958. 790p., $10.75.)

HOW TO TROUBLESHOOT A TV RECEIVER, 2ND ED.

New subjects in this revised edition include portable TV receivers, vertical chassis, and printed circuits. The volume is concerned more with the location of the fault in the receiver than its repair. (J. R. Johnson. New York, Rider, 1958. 150p., $2.50.)

METALLIC RECTIFIERS AND CRYSTAL DIODES

A comprehensive discussion of the principles and practices of metallic rectifiers and crystal diodes, their applications and practical possibilities. (Theodore Conti. New York, Rider, 1958. irreg. paging, $2.95.)

*INTRODUCTION TO A STUDY OF MECHANICAL VIBRATION, 2ND REV. ED.

Reviews the elementary theory of mechanical vibrations as well as some of the more important vibration problems encountered in practice. This edition deals in greater detail with vibration amplitude in rotary machines and with the principles of and the instruments for the measurement of vibrations. (C. W. Van Santen. Galt, Brett-Macmillan, 1958. 310p., $8.50.)

*PRESTRESSED CONCRETE: THEORY AND PRACTICE

Discusses structural analysis, design, and current practical procedures; tanks and pipes; bridge deck analysis; deformation of prestressed concrete and transmission length; overload, ultimate strength and partial prestressing; unit mold and long-line systems; the Lee-McCall, Freyssinet, Magnel-Blaton, Gifford-Udall, and other systems; friction; anchorage stresses; roads and runways. (P. B. Morice and E. H. Cooley. Toronto, Pitman, 1958. 394p., 57/6.)

*CAUSES AND PREVENTION OF CORROSION IN AIRCRAFT

Considers such aspects as causes and prevention of corrosion in engines; corrosion in electrical equipment; the electroplating process; anodic oxidation of aluminum and chromating of magnesium;

• LIBRARY NOTES

metallizing processes; paints, enamels, varnishes and resins for protecting aircraft components; non-destructive examination. (T. C. E. Tringham. Toronto, Pitman, 1958. 124p., 25/-.)

*AERODYNAMICS OF SUPERSONIC FLIGHT, 2ND ED.

Covers flow in a duct, two-dimensional flow, the oblique shock, approximate theories, supersonic wind tunnels, three dimensional flow, and performance calculations. This new edition contains additional material on the aerodynamic theory and the design of a simple supersonic wind tunnel as well as various revisions throughout the text. (A. Pope. Toronto, Pitman, 1958. 243p., $3.55.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Architecture
Small house designs. Ottawa, Central Mortgage and Housing Corporation, 1958.

Asbestos
The Canadian asbestos industry, by E. J. Bonkoff. Toronto, General Research Associates, 1958.

Awards
Scott Turner; Hoover medalist 1957. New York, Hoover Medal Board of Award, 1957.

Construction industry
Should private firms plan public works? by Robert Moses. (Reprint from the New York Times Magazine of Nov. 16, 1958) (Some copies available in the EIC library.)

Foundations
Tables for the calculation of passive pressure, active pressure and bearing capacity of foundations, by A. Coquot and J. Kerisel. Paris, Gauthier-Villars, 1948. 960 fr.

Mathematics
Cours d'exercices sur le calcul mathematique: algebrique, differentiel and integral, by M. Laboureur. Paris, Librairie Polytechnique Ch. Beranger, 1955.

Graded examples in mathematics for national certificate students, by E. G. Shalders. Books 1, 2, and 3. London, Blackie, 1958. 5/- each.

New periodical
The first issue of Jl. of Engineering for Power, one of a series of new quarterly publications initiated by The ASME appeared in Jan. Other quarterlies to be issued by the Society during the year under the general heading, Transactions of the ASME, will be Jl. of Engineering for Industry, Jl. of Basic Engineering, Jl. of Heat Transfer and the long-established Jl. of Applied Mechanics.

Porous materials
Effect of temperature distribution on moisture flow in porous materials, by W. Woodside and J. M. Kuzmak, Ottawa, N.R.C., Division of Building Research, 1958. (Research paper no. 68) 10c

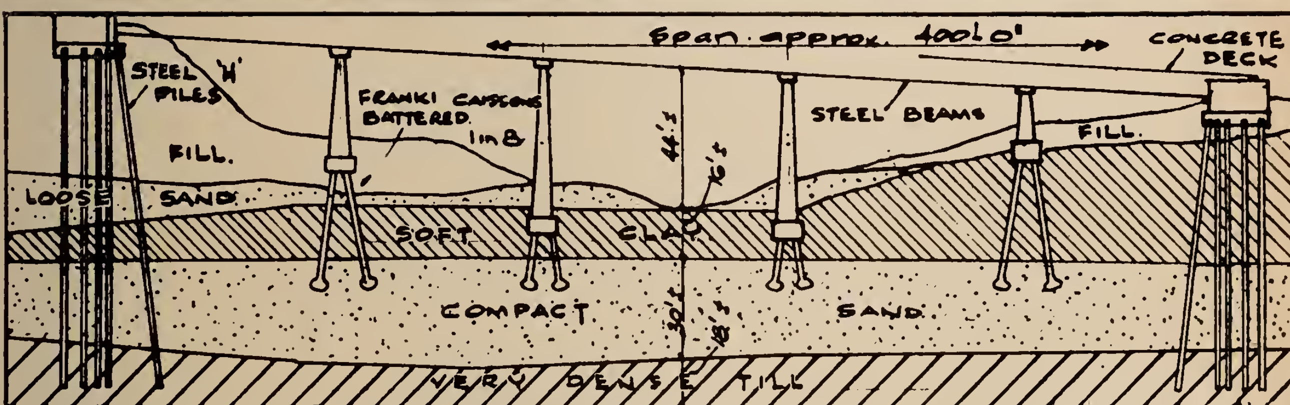
A possible force mechanism associated with the freezing of water in porous materials, by L. W. Gold. Ottawa, N.R.C., Division of Building Research, 1958. (Research paper no. 66) 25c

Sscholarships
Report on university support for science, engineering and medicine for the 42nd year of operation, 1958-59. Ottawa, N.R.C., 1958. 50c

Soil mechanics
Soil moisture tension and ice segregation by E. Penner. Ottawa. N.R.C., Division of Building Research, 1958. (Research paper no. 67) 25c

RANKI FACTS

Franki Caissons Overcome Don River Bridge Pier Foundation Problem



PROJECT:	Bridge
OWNER:	D.H.O.
LOCATION:	Don River and H'way 401—Toronto
GENERAL CONTRACTOR:	Steed & Evans Ltd. Maple, Ontario
NO. OF FRANKI CAISSONS:	112
WORKING LOAD:	100-tons
ERAGE CONCRETED LENGTH:	15'-25'
NO. OF STEEL-H PILES:	120
AVERAGE LENGTH:	72'

Problem

To arrive at the most practical and economical foundations for bridge piers which had to be built over 30' of compact sand topped by about 16' of soft clay. (See sketch.)

Solution

Franki Caissons were used for the pier foundations, obtaining high load capacity in the permeable sand layer, at economical depths.

For the abutments, with lighter loads and a considerable thickness of compacted fill to penetrate, Steel-H Piling was used. To obtain adequate bearing, the Steel-H piles had to be driven to the till.

This illustrates well the considerable saving in length and cost that can be achieved by using Franki Caissons where the soil is granular.

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.

FRANKI

OF CANADA LIMITED

Head Office: 187 GRAHAM BLVD., MONTREAL 16, P.Q.

QUEBEC OTTAWA TORONTO EDMONTON VANCOUVER

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations.

MANITOBA

Public Relations

by R. W. Hutchinson, P.Eng.
From *The Manitoba Professional Engineer*, March, 1959, an abstract.

The public respect afforded the profession is proportional to the effectiveness of its public relations program. The engineering profession, perhaps more than any other, has a need for a solid public education program. Our very name "engineer" has a broad application used to describe anybody from a locomotive operator to a rocket scientist. Most of us do not deal directly with the public and hence our exact function is not clear to many people.

The responsibility of good public relations rests not only with Council and the public relations committee, but also with the membership at large. One of the most encouraging signs in recent years is the increased interest the professional engineer of Manitoba is showing in his Association. For example our Committee is at present offering a career advisory program for high school students. The response to our request for speakers has been most gratifying and this program is providing sound guidance for future engineers as well as helping many professional engineers to develop their ability to speak in public and enhance their profession.

QUEBEC

Results of the 1958 Salary Survey

The BULLETIN of the Corporation of Professional Engineers of Quebec features tables and graphs illustrating the findings of the survey it made last year.

These notes are given:

Median salary of Quebec engineers did not change from last year; it remained at $7,800, after experiencing increases in 1957, 1956 and 1955.

Average of the changes in income earned at the median level *by years of engineering experience* amounted to a 0.7% increase as against 5.1%, and 7.8% in 1957 and 1956 respectively.

Average of the changes in income earned at the median level *by each year of graduation or equivalent* amounted to a 4.6% increase as against 9.3% and 12.2% in 1957 and 1956 respectively.

Consulting remained the field of work where earnings are the highest; median income of engineers engaged in this field was $8100, and 25% of them had earnings equal to or greater than $12,000.

Engineers holding executive positions form the best-paid group; median income of these engineers was $10,850.

Figures clearly show that, as time progresses engineers 'migrate' from nonsupervisory work into work of a supervisory nature and eventually into managerial functions.

If we had to select a 'typical Quebec P.Eng.', using as the basis the information made available through the survey, the engineer selected would have graduated in the last ten years and would have supervisory responsibilities in industry.

BRITISH COLUMBIA

The University and You,

by G. E. Baynes, P.Eng.
An editorial in *The B.C. Professional Engineer*, February, 1959.

A committee of engineering graduates was recently established by the U.B.C. Alumni Association to discuss with the University the appointment of a new Dean of Applied Science. This committee consisted of Harold P. Moorhead, P.Eng., Rod Lindsay, Dave Brousson, Terry Lynch, Alumni Director John Haar, and the writer.

Our help to the University was almost significant and we believe that it will be difficult to replace a man of Dean Henry Gunning's calibre.

However, what we did learn about the problems of the University, and particularly of the engineering faculty, was most revealing.

There is no doubt that our university is suffering from a bulge in population. There are now 1,100 in Applied Science, all endeavouring to become engineers, and some with almost insurmountable handicaps. Some commute twice each day through our time-wasting traffic, others live in substandard basements or attics. Because of this congested living and travelling not more than ten percent of these students take part in any sport or club facility offered on the campus. Few of these young men ever really know their professors or know their university.

Our country has many resources, but perhaps the most important of all is the young man capable of advanced training. This training has never been easy, but there must be a limit to the frustrations that a young student can endure.

There is a real need for standard, student, living accommodation on the campus. The dormitories now under construction are the first of the men's residences and will only meet a small fraction of the requirements.

It is most vital that the teaching be maintained and the provincial budget be extended to meet this requirement. There is a need for more bursaries and scholarships to overcome the proposed raise in student fees.

Your university needs your interest and your help. We must ensure that talent is not lost or frustrated through removable circumstances.

ALBERTA

President Govier Comments

From *The Alberta Professional Engineer*, January, 1959, an abstract.

The engineer's role in the development of the natural resources of a country is one of great importance. It is his technical knowledge and skill which guides both the exploratory effort required to find the resources and the plans and designs for the subsequent development of them. Moreover, although perhaps less well appreciated, it is on the confidence placed in his honesty, integrity and ethics that projects for the development of resources are financed.

But the engineer's value is by no means restricted to his technical contribution. Projects for the development of natural resources require money, often in very large amounts. This money is made available by corporations, the general public, or from government, only when the project is judged to be worthwhile.

The judgment of the practicability of projects of this kind is ordinarily based upon valuation and feasibility studies prepared by professional engineers. These studies are accepted by corporation management, financial houses and security commissions primarily because of the confidence which is placed in the honesty, integrity and ethics of the Professional Engineers. Thus in the last analysis it is the professional qualities of the engineer which enable the projects incorporating his scientific and technical solutions to proceed. We in the profession must protect our good name not only by maintaining high technical standards but also by jealously guarding our professional ethics.

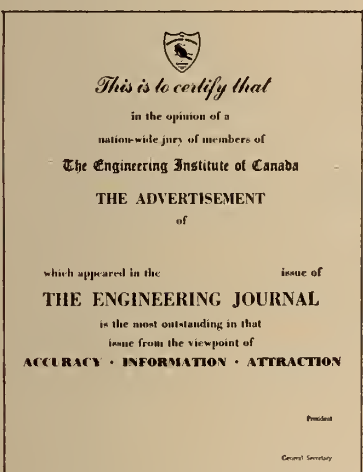
E.I.C. Advertising Award

First judging of "Journal" Advertisements Results in a "Tie"

In January of this year the Institute commenced the monthly award of certificates for the best advertisements in the current issues of the "Journal".

Each month, fifty readers are being asked to study the advertising pages to select the advertisement which is, in their opinion, the best from the viewpoints of ACCURACY — INFORMATION — ATTRACTION. The names of the judges are picked, at random, from the various provincial mailing lists — five names per province.

The judging of the advertisements in the January issue resulted in a tie in the number of votes for two advertisements — Dominion Bridge Co. Limited — a two-page advertisement on pages 78-79, and Peacock Brothers Limited (Rockwell-Nordstrom Valves), also a "double page spread", on pages 16-17. To each of these companies, a certificate of merit will be presented.


This is to certify that
in the opinion of a
nation-wide jury of members of
The Engineering Institute of Canada
THE ADVERTISEMENT
of
which appeared in the issue of
THE ENGINEERING JOURNAL
is the most outstanding in that
issue from the viewpoint of
ACCURACY · INFORMATION · ATTRACTION
President
General Secretary

E.I.C. CERTIFICATE
The certificate, which measures 8½" x 11½", is awarded each month to the advertisers whose advertisements are judged the best in the current issue. These certificates are completed with the name of the advertiser and the issue in which the advertisement appeared. All advertisements appearing in the "Journal" are eligible for the award.

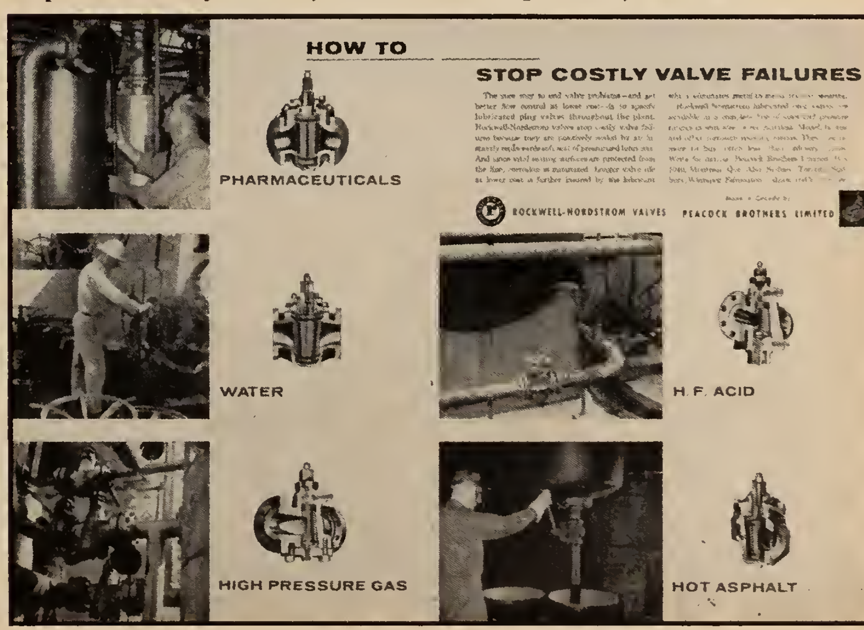
The main purpose of this judging is to gain a good cross-section of opinion as to the type of advertisement which has the strongest appeal and is of the greatest use to Canadian engineers. The various advertisers, and their agencies, will be kept informed as to the opinions of the judges — whose names will not be divulged — so that they will know the type of advertising message most acceptable to our readers.

This opportunity is taken to thank those readers who have already served as "judges" and to ask all who may receive a request to serve the Institute in a similar manner to return the questionnaires they receive within five days of receipt.

Congratulations are extended to the Dominion Bridge Co. Limited and Peacock Brothers Limited on the winning of the first Engineering Institute of Canada Certificate of Advertising Merit.

DOMINION BRIDGE ADVERTISEMENT
This advertisement, which appeared in the January issue of The Engineering Journal, tied for the greatest number of votes for the best advertisement in the issue. The jurors were fifty members of the Institute. The advertising agency, which placed the advertisement, is McKim Advertising Limited, Montreal.

PEACOCK BROTHERS ADVERTISEMENT
This advertisement for Rockwell-Nordstrom Valves tied for first position, with an advertisement of Dominion Bridge Co. Limited. Both advertisements appeared in the January issue. The advertisement was prepared by Marsteller, Rickard, Gebhardt & Reed, Inc., Pittsburgh, Pa., and was placed in the "Journal" by McKim Advertising Limited, Montreal.



awarded a $9,000,000 contract for production of height-finding radar equipment for the Pinetree radar line in Northern Canada to the Canadian General Electric Company Ltd. The equipment will be part of the integrated defence system of the continent. Most of it will be built at the Royce Works plant in Toronto, but some will be contracted to Canadian suppliers.

Nylon Automobile Parts — Almost 250 different items in some of this year's cars are made of "Zytel" nylon resin, according to Dupont of Canada Limited (Box 660, Montreal). The total weight of all parts made of this material and used in the average new car is less than one pound.

Nitrile Silicone Rubber — NSR-X5602, the first product in the new family of G-E Nitrile silicone rubbers, is now available from Canadian General Electric's Chemical Department, 940 Lansdowne Avenue, Toronto. It is intended for intermittent contact with high-swell fluids or continuous immersion in milder fluids. It is described as having "intermediate fluid resistance". NSR-X8701 available in March; NSR-X4803 is available in April.

RTV silicone rubber, recommended for electrical potting and encapsulating and for high and low temperature sealing and caulking is described in CBS-170, a new bulletin available from Chemical Materials Section, Canadian General Electric Company (940 Lansdowne Ave., Toronto).

Railway Operating Deficit — The Canadian National System shows operating revenues for January 1959 as $55,676,000; expenses, taxes and rents, $60,422,000; and a net operating deficiency $4,746,000.

Gate Valves — Crane Limited has initiated the manufacture of valves of top quality to meet A.W.W.A. specification, according to the company. To conform with various types of joints they are available in several types of end connections. For literature on Crane A.W.W.A. double disc gate valves, contact Crane Limited, 1170 Beaver Hall Square, Montreal.

New Chemical Plant — Expansion of its facilities in Eastern Canada is being made by Electric Reduction Company of Canada, Ltd. The next stage involves a multi-million dollar expenditure for plants to produce sulphuric and phosphoric acids, sodium phosphates and other products. These plants will be located at Port Maitland, Ont. Sodium chlorate expansions have recently been completed for the company at Buckingham, Que. and Vancouver, B.C.

Public Transportation System — Quebec Power Company has sold its 100 per cent ownership of shares of Quebec-Autobus Ltee, which operates the public transportation system in Quebec City, to Transport Regional Ltee.

New Ownership — Union Carbide Canada Limited and Shawinigan Chemicals jointly announce that Shawinigan Chemicals Limited has become sole owner of Canadian Resins and Chemicals Limited, through acquisition of Union Carbide Canada Limited's 51 per cent interest.

Union Carbide will continue to produce and sell plastics through its two divisions—Bakelite Company and Carbide Chemicals Company.

The acquisition will permit integration of Canadian Resins and Chemicals' operations with those of Shawinigan Chemicals, whose plants are in proximity.

New Grinder — Atlas Copco Canada Ltd., Montreal Airport, Quebec, has added a new 8 in. extra-heavy duty grinder to its line of pneumatic tools. Its patented non-wearing governor has no contact between rotating and stationary parts. The machine also has a safety coupling which disconnects the wheel spindle from the motor. Other features are a built-in lubricator, and exhaust silencer and special light alloy body parts.

New Control Plan — Canadian National Railways has implemented a new method of motive power control across its system. The innovation is expected to result in more efficient operation, considerable savings, and more advantageous placement of power.

Atomic Engine for A-Sub — Canadian Westinghouse Company Limited advises that Westinghouse Electric Corporation will supply the atomic engine to drive Britain's first atomic submarine, the Dreadnought. Agreement has been reached between Rolls Royce Limited and the American firm.

Change of Name — Linde Air Products Company, Division of Union Carbide Canada Limited, has deleted the words "Air Products" from its name. Since February 1st, 1959, this company is known as Linde Company, Division of Union Carbide Canada Limited.

Fibre Tubes in Overpass. — "Sonovoid" fibre tubing, a product of Sonoco Products of Canada Limited, is being used in the construction of the elevated portion of the Metropolitan Boulevard, Montreal. The order for the tubing is the largest the Company has received in any part of the world.

The elevated portion of the Boulevard is six miles long and approximately 700,000 ft. of 26 in. tubing will be used. The 60 ft. span which has been developed for this structure is another Canadian "first". The design and specification was prepared by Brouillet, Carmel and Boulva.

The "Sonovoid" slab system, which has many uses, utilizes void tubing to create a symmetrical system of cylindrical air cells, within the concrete slab, to remove mass and weight of non-working concrete at the neutral axis—it introduces a system of successive "T" beam sections to carry the load.

For complete information on "Sonovoid" and its applications, write to Sonoco Products of Canada Ltd., Brantford, Ont.

the engineering institute of canada

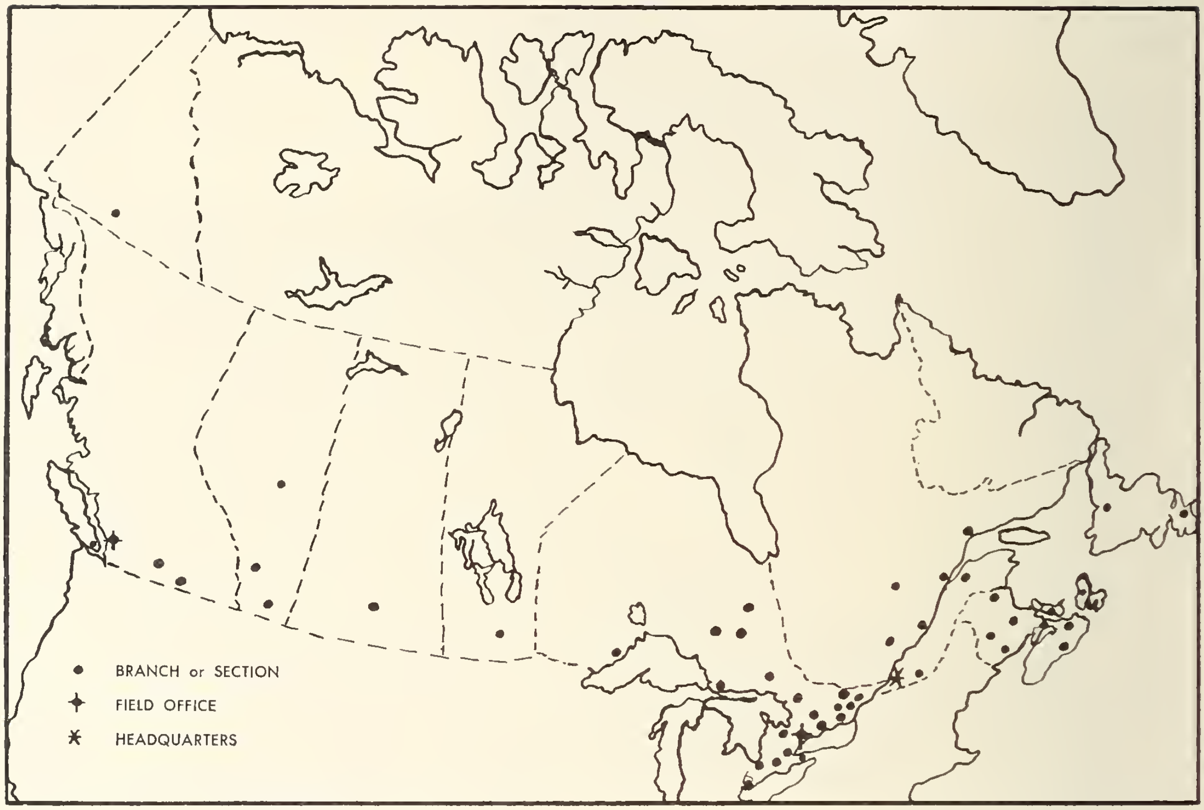
1958

REPORT OF COUNCIL

and reports of committees and branches

LISHED AS A SUPPLEMENT TO THE ISSUE OF *THE ENGINEERING JOURNAL* FOR APRIL NINETEEN HUNDRED FIFTY-NINE

The Engineering Institute of Canada



This institute has a voluntary membership of over 18,000 engineers, maintains 50 branches from Newfoundland to the Yukon, publishes the Engineering Journal and other literature, and has achieved international eminence as one of the front ranking engineering societies of the world. It is devoted to the following purposes:—

"To facilitate the acquirement and interchange of professional knowledge among its members, to promote their professional interests, to encourage original research, to develop and maintain high standards in the engineering profession and to enhance the usefulness of the profession to the public."

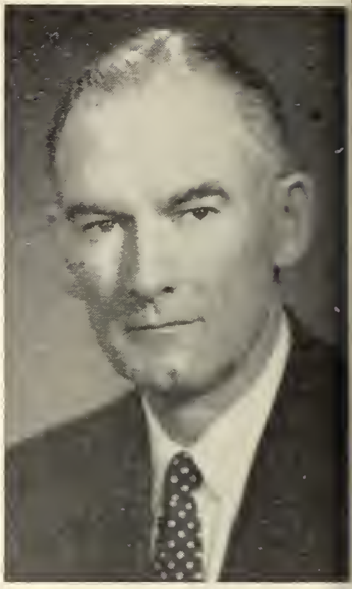
THE ENGINEERING INSTITUTE OF CANADA

annual report

for the year ended December 31 1958

contents

LETTER FROM THE PRESIDENT



LETTRE DU PRESIDENT

WITH THIS LETTER there is transmitted to each of the 18,542 members of The Engineering Institute of Canada the report of the operations of your Institute for 1958 — its 72nd year of service.

Please read this report carefully, because it contains, in an organized form, a statement of your Institute's activities and accomplishments for the year. These constitute a real record of achievement, and demonstrate vividly what the E.I.C. does for you, for the profession and for the nation, both at home and in the world scene.

When you have read the report, I trust that you will join with me in taking increased interest and pride in Canada's largest technical society — The Engineering Institute of Canada. I trust that you will also join me in expressing appreciation to the hundreds of members whose efforts have made this fine record of achievement possible. This includes the Past-Presidents, Council members, Committee members, the many local officers, faculty advisors, and our representatives on the technical committees of other societies and organizations. Our thanks are also due the staff, who have rendered good service in their respective capacities.

Nous transmettons ci-joint à chacun des 18,542 membres de l'Institut le rapport annuel de l'année 1958, la 72ème de son existence dévouée au service de la profession de l'ingénieur et du Canada.

Veuillez lire ce rapport avec attention parce qu'il relate, sous une forme concise et facile à interpréter, l'oeuvre accomplie par votre Institut durant l'année qui s'achève. Ce palmarès constitue un véritable record et montre sans équivoque ce que l' "Engineering Institute of Canada" est en mesure d'accomplir pour vous, pour la profession et pour le pays, tant au point de vue national qu'au point de vue international.

Je suis convaincu qu'après la lecture de ce rapport, vous voudrez prendre une part plus active à nos travaux, et que vous éprouverez des sentiments de fierté à être membre de la plus importante société technique du Canada, l' "Engineering Institute of Canada". Je suis sûr que vous vous joindrez à moi pour féliciter le grand nombre de nos membres qui, par leurs efforts, ont contribué à un essor aussi remarquable de notre Institut. Je pense à nos anciens présidents, aux membres du conseil, aux membres des comités, au grand nombre d'officiers de nos chapitres locaux, à nos représentants dans les facultés de génie et à tous ceux qui ont travaillé en notre nom avec d'autres sociétés professionnelles et techniques. Nous remercions aussi le personnel de l'Institut qui, dans l'exercice de ses fonctions, nous a rendu des services à signaler.

K. F. Tupper, M.E.I.C.,
President

The Engineering Institute
of Canada.

REPORT OF COUNCIL

ADMINISTRATIVE SERVICES

ACTIVITIES OF THE PRESIDENT

In the spring of 1958, Dr. C. M. Anson completed his presidential visit to a large number of branches. He interrupted his travel in this country for six weeks to represent the E.I.C. at the Conference of Engineering Institutions of the British Commonwealth, held in Australia and New Zealand, March 19 to April 2.

En route to Australia, on February 10, 1958, Dr. Anson unveiled the E.I.C. memorial to the late H. J. Cambie, a bronze plaque prominently situated in the Canadian Pacific Railway station in Vancouver, B.C.

Shortly after assuming the office of President for 1958-59 in May, Dr. K. F. Tupper represented the E.I.C. at the annual meetings of The Chemical Institute of Canada in Toronto and of the Royal Architectural Institute of Canada in Montreal, and at the Fiftieth Anniversary celebrations of the American Institute of Chemical Engineers in Philadelphia. Later in the year he represented the E.I.C. at the annual meetings of the American Society of Civil Engineers and the American Society of Mechanical Engineers in New York City. At the latter he held a reception for Canadian engineers and their ladies present at that meeting, and for officers and senior members of sister U.S. engineering societies.

In response to an invitation from the government of the U.S.S.R. and with the approval of the Canadian government and the E.I.C. Council, Dr. Tupper visited the U.S.S.R. for two weeks in October to discuss arrangements for the exchange of teams of engineers between the two countries. En route to the U.S.S.R. Dr. Tupper presented the greetings of the E.I.C. to the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers in London, The Société Royale Belge des Ingénieurs et des Industriels, in Brussels and the Danish Institution of Civil Engineers in Copenhagen.

After returning from the U.S.S.R., Dr. Tupper visited about one-half of the Institute's branches and student sections before the end of the year, covering most of Eastern, Central and mid-Western Canada.

COUNCIL

Council met 11 times in 1958, including one plenary meeting in May devoted to Confederation. The average attendance at Council meetings in 1958 was 24.

The Councillors in Zone "A" (Western Canada) met twice, in March and in October, to consider Institute problems particular to the Zone, and to prepare appropriate recommendations to Council.

COMMITTEES

The committees appointed by the Council continued to contribute to the efficiency of the Institute's operation. Not only do they study proposals which have been referred to them by Council, but in various ways each keeps in touch with situations and attitudes within its terms of reference and, when necessary, initiates considered action.

All standing and special committees were active during the year, their reports appear on pages 16 to 23 of this report.

FINANCE

The financial results for the year 1958 were somewhat disappointing. Expenditure exceeded revenue and consequently a deficit was incurred on the year's operations. The appreciable increases in administrative expenses arose chiefly through expanded activity at both the local and the international level. Total revenue was less than in the previous year due to a reduction in advertising revenue.

HEADQUARTERS

On January 1, 1958, Colonel L. F. Grant retired as Field Secretary after making a magnificent contribution to Institute activities for many years. Particularly noteworthy was his contribution to the very successful professional development programs operated by a number of branches, and which are due in large measure to his initial inspiration and guidance. Mr. John McLaren became Eastern Field Secretary in January, 1958.

May 30, 1958, marked the completion of twenty years of outstanding service as General Secretary by Dr. L. Austin Wright. On Dr. Wright's retirement on this date, he was succeeded as General Secretary by Dr. Garnet T. Page. Dr. Wright was retained by Council as General Consultant to assist and advise the President and General Secretary on request.

The Eastern Field Secretary

All but 7 of the 40 branches of the Institute east of the Manitoba border were visited. Visits have also been made to many of the engineering colleges, where calls were made on members of the faculty and talks given to student bodies about the work of the Institute, along with showing of films on current engineering projects. Considerable time was also spent assisting in the organization and operation of branch professional development programs.

Wherever possible stops were made to visit "orphan" members who by reason of distances from the place of branch meetings have little contact with the E.I.C. except through the Journal. Altogether, over 19,000 miles were travelled in connection with the work of the Institute.

Many calls were made on the Toronto office to assist in locating employment. In the earlier part of the year, many engineers found it necessary to seek positions and this office assisted them, in conjunction with the employment service at headquarters, by suggesting possible sources of new employment. Toward the end of the year, requests for employment service diminished considerably.

The Toronto office was used frequently for committee meetings of technical sections and professional development courses.

The Western Field Secretary

During 1958 the following Branches, Sections and unorganized groups were visited, some of them more than once:— Victoria, Vancouver, Chilliwack, Powell River, Kelowna, Penticton, Trail, Lethbridge, Calgary, Edmonton, Medicine Hat, Swift Current, Moose Jaw, Regina, Saskatoon, Prince Albert, Brandon and Winnipeg.

The impression gained on these visits is that, with one or two exceptions, the sense of isolation felt by Zone "A'" groups is decreasing.

This desirable trend can be ascribed to a variety of causes such as periodical Regional meetings of Councillors, more frequent visits by Institute Officers and staff; in other words, to better communications. It is also considered that the recent prominence of discussion on Confederation has tended to awaken interest and understanding in the National, rather than the Provincial character of the profession.

The Annual Meetings of the Associations of Professional Engineers in Alberta and Saskatchewan were attended by invitation and in both cases a warm welcome was received.

Two meetings of Councillors of Zone "A" were held during the year, one in Edmonton in March and one in Calgary in October. Both were fruitful and they appear to serve a very useful purpose.

At the Calgary meeting the decision was taken to hold a Zone "A" Regional Technical Conference at Banff on October 2nd - 3rd 1959 and Calgary has consented to act as Host Branch.

Assistance was rendered to professional development courses which are operating or being planned in Winnipeg, Edmonton, Calgary and Vancouver.

The employment situation for engineers in B.C. was very bad, compared to recent years, for most of 1958, though it has shown some slight improvement toward the end of the year. Many calls were made on the Vancouver office for help in securing employment.

MEMBERSHIP

The total membership at the end of 1958 was 18,542, representing a net increase of 991 over the previous year. The ratio of gains to losses was approximately 2.2:1. Gains include admissions and reinstatements. Losses include resignations, removals and deaths.

The continued growth in total membership was due in large measure to the efforts of the branch membership committees in recruiting candidates for corporate membership, and to the Student Representatives and Faculty Advisors who conducted drives for student membership.

Table I indicates the increases in the various classes of membership during the year and shows the losses by resignations and removals.

Deceased Members

During the year 1958 the deaths of members of the Institute (including four Honorary Members) have been reported as follows:

Honorary Members

Doane, Francis William Whitney, Halifax, N.S.
Gibb, Sir Alexander, Westminster, London, England.
Gray, Francis William, Victoria, B.C.
Pratley, Philip Louis, Montreal, P.Q.

Members

Addie, George Kyle, Quebec, P.Q.
Agar, George, Montreal, P.Q.
Allingham, Ralph R., White Plains, N.Y., U.S.A.
Altrogge, Alfred Joseph, Saskatoon, Sask.
Ballantyne, Norman Frank, Ottawa, Ont.
Bash, Kenower Weimer, Toronto, Ont.
Bickerdike, Robert, Westmount, P.Q.
Bush, Harold Frederick, Montreal, P.Q.
Camsell, Charles, Ottawa, Ont.
Clarke, Ernest R., Scarborough, Ont.
D'Aoust, Joseph Gilbert, Powell River, B.C.
Davy, Richard Frederick, Victoria, B.C.
Dickenson, John Goodall, Toronto, Ont.
Douglas, George Vibert, Toronto, Ont.
Edington, William James, Moncton, N.B.
Elgee, Herbert Alcock, Budleigh, Devonshire, England.
Faulkner, Charles Frederick Peter, North Surrey, B.C.
Flynn, James Emmett, Vancouver, B.C.
Forgie, James, Kew Gardens, N.Y., U.S.A.
Fowlie, Cecil Winston, Halifax, N.S.
Fry, Albert Edward, Montreal, P.Q.
Fulton, Edward Arthur, St. Louis, Missouri, U.S.A.
Furlong, Henry Walter, Wollaston, Mass., U.S.A.

MEMBERSHIP STATISTICS

	1958	1957	Net Increase
Honorary Members	38	37	1
Members	8005	7822	183
Juniors	6292	5989	303
Students	4150	3647	503
Affiliates	57	56	1
Total	18,542	17,551	991

Resignations and Removals:	Members	Juniors	Students	Total
Resigned (no arrears)	97	133	59	289
Resigned (arrears)	32	42	18	92
Removed, unpaid fees	36	134	56	226
Removed, no address	24	77	55	156
Removed, Students over-age			41	41
Total	189	386	229	804

Reasons Given for Resigning:	
No reason given	120
Resignations through Association agreements	47
Left Canada	41
Students Left Engineering and Over-age	45
Retired or not Practising	39
Unable to Participate	28
Financial	25
Other Interests	18
Prefer A.P.E. membership only	5
All others	18
Total	386

TABLE I

Gage, Edward Victor, Montreal, P.Q.
Gilchrist, T. E., Peterborough, Ont.
Gibb, Robert James, Edmonton, Alta.
Haanel, Benjamin Franklin, Ottawa, Ont.
Haltalin, Clifford Paul, Winnipeg, Man.
Hatfield, George N., Saint John, N.B.
Hays, David Walker, Medicine Hat, Alta.
Hogg, Thomas H., Toronto, Ont.
Hunter, John Samuel, Calgary, Alta.
Innes, Edward Patrick Nelles, Hamilton, Ont.
Jane, Robert Stephen, Montreal, P.Q.
Joy, Douglas Grahame, Toronto, Ont.
Keay, Herbert O., Sudbury, Ont.
Keith, Fraser Sanderson, Smiths Falls, Ont.
Kennedy, Michael Sylvester, Victoria, B.C.
Kirkpatrick, Paul Chester, Baie d'Urfee, P.Q.
Kresz, Francis Charles, Toronto, Ont.
Laffoley, Laurence Herbert, Montreal, P.Q.
Lang, Edwin George Power, Montreal, P.Q.
Lanouette, Marcel Guy, Rimouski, P.Q.
Lawson, Wilfrid S., Ottawa, Ont.
MacArthur, John Alexander, Montreal, P.Q.
MacConnell, Howard Bruce, Fort William, Ont.
MacDonald, Arthur Lamond, Montreal, P.Q.
MacGillivray, John Alexander, Willowdale, Ont.
MacMahon, James W., Westmount, P.Q.
Malcolm, Alvin Lawrence, Campbellford, Ont.
Maple, Harold Ernest, Ottawa, Ont.
Milne, Winford Gladstone, Hamilton, Ont.
Montgomery, Samuel Clifford, Trail, B.C.
Mugaas, Henrik, Meaford, Ont.
Murphy, John J., Ottawa, Ont.
Murphy, Stephen John, Ottawa, Ont.
McCammon, John Whyte, Montreal, P.Q.
McGinnis, Thomas Alexander, Kingston, Ont.
McGruer, Alfred Edwin, Montreal, P.Q.
McLean, William Brown, Lachine, P.Q.
Norton, Charles Douglas, St. Lambert, P.Q.
Oddleifson, Axel Leonard, Fort Garry, Man.
Pariseau, Louis Stanislas, Montreal, P.Q.
Paszkiewicz, Jerzy, Montreal, P.Q.
Plummer, Alexander Alfred, Vancouver, B.C.
Raskin, Franz Joseph, Montreal, P.Q.
Rayner, George William, Toronto, Ont.
Reid, Alexander MacLaren, Edmonton, Alta.
Ripley, Blair, Victoria, B.C.
Roberts, Stanley O., Ottawa, Ont.
Sorby, Walter Oswald, Halifax, N.S.
Shaw, John Aitken, Hudson Heights, Que.
Stairs, Gordon Salter, Halifax, N.S.
Sutcliffe, Homer Wilson, New Liskeard, Ont.
Tempest, Frank C., Calgary, Alta.
Templeman, George Earl, Montreal West, P.Q.
Theriault, Antonin, Quebec, P.Q.
Thompson, Howard Grant, Mallorytown, Ont.
Thomson, Lesslie R., Montreal, P.Q.
Vaughan, Frank P., Saint John, N.B.
Vaughan, Harold Wilfred, Montreal, Que.
Whillans, Thomas O., Ottawa, Ont.
White, John Robertson, Cornwall, Ont.
Wilson, William Smith, Sydney, N.S.

Juniors

Bond, Raymond Arthur William, Isle Maligne, P.Q.
Dion, Roland, Charlesbourg, P.Q.
Larouche, Pierre Michel, Chicoutimi, P.Q.
Moran, Frank Patrick, Vancouver, B.C.
Niazi, Mohammed Abdul Qayyum Khan, Lahore, West Pakistan.
Stanbridge, Mathew James, Winnipeg, Man.

Students

Cote, Aime Georges Denys, Sherbrooke, P.Q.
Highgate, Robert Allen, Wallaceburg, Ont.
Joyce, Bruce Edward Clive, Bedford, N.S.
Valiquet, Joseph Georges Jean, Ottawa, Ont.

DISTINGUISHED FOREIGN VISITORS

During 1958 the Institute was pleased to receive many important visitors from abroad. Among them were:

Sir Arthur Whitaker, and Alexander McDonald, President and Secretary respectively of the Institution of Civil Engineers, of Great Britain.

J. M. Landis, President, American Society of Mechanical Engineers.

O. B. Schier II, and T. A. Marshall, Secretary and Senior Assistant Secretary respectively of the American Society of Mechanical Engineers.

L. R. Howson, and Wm. Wisely, President and Executive Secretary respectively of the American Society of Civil Engineers.

W. J. Barrett, President, American Institute of Electrical Engineers.

E. R. Needles, President, Engineers Joint Council, N.Y.

W. K. Brasher, Secretary, Institution of Electrical Engineers, of Great Britain.

All of the foregoing gentlemen, some with their wives, were guests at the Annual Meeting, Quebec. Others, who made our acquaintance on different occasions, included —

Frederick Snow, Past president, Institution of Structural Engineers, of Great Britain.

Ove Guldberg, Secretary, Institution of Danish Civil Engineers.

James Newby and Dr. H. V. Walters, both of the I.A.E.S.T.E. Committee of Great Britain, of which Mr. Newby is Executive Secretary.

Sir George Barnett, Head of factory inspection for the British Government.

D. P. R. Cassad, President, Institution of Engineers, India.

E. A. Nadirshah, past-President, Institution of Engineers, India.

Luis Giannattasio and James M. Todd, President and Vice-President respectively of U.P.A.D.I.

R. H. Richmond and E. D. McWalker, both of the State Rivers and Water Supply Commission of Australia.

CONFEDERATION

The following is a progress report on Confederation for 1958:

Council's special Committee on Confederation, working in collaboration with a similar committee appointed by the Canadian Council of Associations and the Corporation of Professional Engineers, has worked steadily toward the production of a definite plan for "Confederation".

On May 19, the Council held a plenary meeting in Quebec City to receive and discuss a report of the joint Committee. Council unanimously accepted seven of the eight clauses, and accepted the eighth clause in principle, subject to further discussions as a guide for future action by its committee. The committee was asked to prepare a statement based on its report and outlining the objectives of the new national body for presentation to and balloting upon by the membership of the Institute and the Associations and Corporation, after approval by the respective councils.

The chairman of the special committee reported to each meeting of Council to keep members of Council informed of progress made by the committee.

At the December Council meeting the chairman of the committee reported that the final report of the sub-committee had been circulated to all members of the joint committee, and that all members have reported that they approve the report in its entirety. It was agreed that a plenary meeting of Council be held at the earliest possible date after distribution of the joint report to members of Council, and this plenary meeting was arranged to take place in Toronto on Saturday, January 31st, 1959.

DIRECT SERVICES

ANNUAL AND REGIONAL MEETINGS

The 1958 Annual General and Professional Meeting was held in May at the Chateau Frontenac in Quebec City. Because of its location and historic interest, Quebec is a popular spot for such gatherings, and those members and guests who participated enjoyed a fine meeting. The total registration of 932 was not the largest on record, but the excellent spirit and enthusiasm shown through the many events will long be remembered.

Although the official duration of the meeting was three days, the program of business and committee meetings, technical sessions, conferences, and social events pretty well filled a five day period. 37 technical papers were presented, on a wide variety of subjects, and the general comment was that the professional meeting was interesting and well-rounded. Special conferences were convened for the deans of engineering, the branch officers, and engineering students. The employment and library services functioned at Quebec throughout the conference.

The social events were highlighted by farewell tributes to the retiring General Secretary, Dr. L. Austin Wright. He was the recipient of several beautiful gifts from the members, and from the twenty Presidents under whom he served. Hospitality was provided again through the courtesy of "Muriel's Room", and the Institute is grateful to the many Canadian firms whose generosity made this possible.

The schedule for future annual meetings is:

1959 Royal York Hotel, Toronto, Ontario, June 8-9-10

1960 Royal Alexandra Hotel, Winnipeg, Manitoba, May 25-26-27

1961 Hotel Vancouver, Vancouver, B.C.

1962 Queen Elizabeth Hotel, Montreal, Quebec, this will be the Seventy-Fifth Anniversary of the E.I.C.

Regional Meetings

The first E.I.C. Southern Ontario Regional Conference was held on March 15, 1958 at the Royal Connaught Hotel, Hamilton. This conference was organized by the Hamilton Branch with the Niagara Peninsula, Toronto, Kitchener, London, Sarnia, and Border Cities Branches participating.

383 engineers and their ladies attended this most successful conference, which combined excellent technical and social programs.

In line with the Institute's policy of expanding its program of regional conferences to bring this type of service to as many members as possible, plans were initiated in 1958 for the following regional conferences:

March 14, 1959	— Hamilton, Ont.
April 25, 1959	— Sudbury, Ont.
October 2-3, 1959	— Banff, Alta.
October 15-16, 1959	— Ottawa, Ont.
May 6-7, 1960	— Kingston, Ont.

In addition, the regular biennial regional conference for members of E.I.C. and the professional associations in the Atlantic Provinces was held at Digby, N.S., September 2-4. It was well attended and was highly successful. The 1960 conference will be held in St. Andrews, N.B. in early September.

AWARDS, HONOURS, MEDALS AND PRIZES

These awards were presented during the annual meeting to those recipients who could be present.

HONORARY MEMBERS

Armand Charles Crepeau, Sherbrooke, Sir Claude Dixon Gibb, Newcastle-upon-tyne, England, Philip Louis Pratley, Montreal, Que., Irving Richard Tait, Montreal, Que., Earle Oliver Turner, Fredericton, N.B., Leslie Austin Wright, Montreal, Que.

JULIAN C. SMITH MEDALS

Richard Edgar Heartz, M.E.I.C., Montreal, Que., Robert Edwards Jamieson, M.E.I.C., Montreal, Que.

ROBERT W. ANGUS MEDAL

Russell J. Kennedy, M.E.I.C., Kingston, Ont.

DUGGAN MEDAL AND PRIZE

Robert David, M.E.I.C., Montreal, Que., G. G. Meyerhof, M.E.I.C., Halifax, N.S.

LEONARD MEDAL

E. O. Lilge, M.C.I.M., Edmonton, Alta.

PLUMMER MEDAL

H. R. L. Streight, F.C.I.C., Montreal, Que.

ROSS MEDAL

Ronald George Griffith, M.E.I.C., Montreal, Que.

H. N. RUTTAN PRIZE

Wilfred Pegusch, JR.E.I.C., Vancouver, B.C.

PHELPS JOHNSON PRIZE

Donald Andrew Chamberlain, JR.E.I.C., Montreal, Que.

ERNEST MARCEAU PRIZE

Gilles Gagnon, JR.E.I.C., Montreal, Que.

JOHN GALBRAITH PRIZE

Charles Murray Stewart, JR.E.I.C., Sarnia, Ont.

MARTIN MURPHY PRIZE

Robert Donald Neill, JR.E.I.C., Fredericton, N.B.

BRANCHES

The inauguration of the Chalk River Branch in May, 1958, was memorable, for this was the fiftieth Branch to be established by the Institute. The fifty branches extend from Newfoundland to Vancouver Island, and provide technical and social programs to the many thousands of members in their areas. Financed in part by rebates of membership fees, the activities sponsored by the branches are the "life-blood" of the Institute.

Almost every branch received either President Anson or President Tupper in 1958, and the headquarters and field staff visited as many branches as possible, to ensure the best possible communications between the branches and the national officers and Headquarters. Headquarters and the field staff continued to work closely with branches by assisting with technical programs, professional development programs, administration matters, records, membership and admissions, stationery and mailings, and groups of engineers' wives.

A successful branch officers conference was held during the 1958 annual meeting at Quebec City. This conference put forward a number of useful recommendations and suggestions to the Council which have been most helpful in the formulation of acceptable policies and programs. Based on the recommendations of this meeting, both in 1957 and 1958, a draft manual for the operation of branches was proposed and circulated to all branches for comment before the final printing, which will be done in 1959.

The Officers, Council and staff wish to acknowledge the great amount of voluntary work done by the hundreds of branch officers and committee members in rendering direct local services to the membership, and for their co-operation in supporting the various national and international projects which depend in large measure on branch support for their ultimate success.

CERTIFICATES FOR MEMBERS

Approximately 190 members received E.I.C. membership certificates, available on request at a cost of $1.25. Later in the year Council decided that all Life Members would be presented with a special certificate of life membership. This new policy will be implemented in 1959.

CO-OPERATION WITH OTHER ENGINEERING AND SCIENTIFIC ORGANIZATIONS

In addition to the formal meetings between representatives of the member societies of such international organizations as UPADI and the Conference of Engineering Societies of the British Commonwealth, the E.I.C. maintains regular and extremely cordial contacts with the Institutions in the United Kingdom, and other Commonwealth societies, the Founder Societies in the United States of America, the representative national engineering organizations in Europe, the far East, and Latin America. These frequent exchanges of information and assistance have proven invaluable to the Canadian engineering profession.

At the national level, the Institute works closely with the Canadian Institute of Mining and Metallurgy, The Chemical Institute of Canada, The Canadian Aeronautical Institute, the Canadian Good Roads Association, and others on a number of important government-sponsored and inter-society projects.

There was no change in the operation of the seven agreements between the Institute and provincial registering bodies in 1958. These agreements have made it possible for administration to be simplified and have resulted in substantial savings and convenience to the members in the provinces concerned.

EMPLOYMENT SERVICE

Employment opportunities for engineers were less numerous in 1958 than during the previous five years, as shown on the following table:

1954	1955	1956	1957	1958
"Situations Vacant"				
228	181	190	297	366
No. of applicants "Situations Wanted"				
400	550	500	350	300

Geographical Distribution Situations Vacant 1958

Maritimes	9	Central Canada	250
Prairies	33	West Coast	8

In addition to the 366 engineers who advertised for employment in the Journal, the employment service assisted 230 unemployed engineers during 1958. The majority of these were recent immigrants to Canada, and others released from industries. Approximately 800 interviews were conducted during 1958 and 65 known placements were made.

1600 copies of the employment bulletin were printed every month — 1100 of these were sent to a standing list of employers of engineers; and 500 distributed to those seeking employment.

One hundred and sixty-five students from all parts of Canada registered for summer employment during January, February and March.

The scarcity of engineering jobs affected the graduating class of 1958. A canvass of the larger employers indicated that, although they were conducting campus interviews across Canada, the number of graduates required would be smaller than in the previous few years. Late in the year, some increase was noted in the demand for engineers. This was reflected by the fifty-five new positions listed in December.

ENGINEERING EDUCATION

3rd Biennial ASME-EIC Conference on Engineering Education

"How Should Industry Aid Engineering Education?" was the theme of the 3rd Biennial Conference on Engineering Education sponsored jointly by ASME and E.I.C. held at the University of Michigan, Ann Arbor, October 15-16, 1958. There were 117 delegates at the Conference of which 33 were from Canada. 11 Canadian universities were represented.

The Conference was divided into three sessions, which took the form of panel presentations followed by general discussion. Past-President C. M. Anson and President K. F. Tupper addressed the delegates at the opening dinner and closing luncheon respectively.

The first panel presentation was on the topic "The Philosophy of Co-operation between Industry and Higher Education". The second panel was on the topic, "Continuing Education by Industry in Industry" and the third panel dealt with "Support by Industry of Higher Education".

Committee on Engineering Education as recommended by the E.I.C. Education Conference, the Council approved the establishment of the E.I.C. Committee on Engineering Education. Seven members representing the universities and seven representing industry have been appointed, with Dean H. G. Conn as interim chairman. This Committee, which will meet for the first time during the 1959 annual meeting in Toronto, shall concern itself with matters of engineering education that come before the E.I.C., and detailed proposals for the scope of the committee will be reviewed for adoption.

Canadian Conference on Education—The E.I.C. was one of nineteen national organizations which sponsored the Canadian Conference on Education held in Ottawa in February. The Institute's representatives participated actively in the workshops on higher education, school buildings and equipment; and teachers—quality and quantity. It was generally agreed that the conference was successful in increasing the public's awareness of Canada's problems in education, in bringing together those concerned with these problems, in stating what some of the basis problems are, and in the establishment of a continuing organization to sponsor constructive action toward the solution of these problems. The Institute is a sponsoring member of the continuing organization of the Canadian Conference on Education.

Engineering Education Conference — The 1958 meeting was held on May 20, in conjunction with the E.I.C. annual meeting at Quebec. Attended by deans of engineering from degree-granting universities, it was chaired by Mr. J. Hoogstraten and was concerned primarily with preparing plans for a major engineering education conference in 1959.

The conference recommended specific terms of reference for the new 14 member Committee on Engineering Education being established by the E.I.C., and named seven academic members to the committee. The other seven members are to be selected from industry by the Institute.

The conference also agreed to place before the National Conference of Canadian Universities a proposal that they establish a committee of engineering educators within the N.C.C.U.

Finally, in the international realm, many useful discussions regarding engineering education were held during the Conference of Engineering Institutions of the British Commonwealth, and the V UPADI Congress and with experts from the the Organization for European Economic Cooperation who visited Canada late in 1958.

General

On a continuing basis, the Institute maintains a close and effective relationship with universities, appropriate agencies of the Federal and Provincial Governments that are concerned with education, with the Canadian Education Association and the Canadian Teachers Federation.

GOVERNMENT LIAISON

In 1958 the E.I.C. continued its close liaison with the Federal Government, working co-operatively with many agencies and departments on a day-to-day basis in the interests of Canadian engineering, and in helping to solve problems referred to the E.I.C. directly either or by virtue of the Institute's membership on committees and boards established by the government. The Institute learned with pleasure that the government had seen fit to appoint senior engineers to a number of important commissions inquiring into important problems affecting the nation's economy and resources.

The list of specific areas of Institute participation is long, including certain technical committees of the National Research Council, the Department of Trade and Commerce, the Department of Labour and the Department of National Health and Welfare; covering such areas as building research, the Colombo Plan, the United Nations Technical Assistance Administration, technical manpower, vocational training, and civil defence. On another level, the E.I.C. is in regular communication with the Civil Service Commission, the Department of External Affairs, the National Film Board and other agencies regarding vocational information, and the dissemination of knowledge about Canada's engineering achievements to other countries.

LIBRARY AND FILM SERVICE

Increased use was made of the library during the year, and the majority of the requests continued to come from members and other libraries in the Montreal area. An average of twenty-five requests were handled a day.

The total number of items circulated by the library during the year was 4,326, an increase of more than 1,000 over 1957. It is interesting to note that about twenty-five per cent of the loans were made to other libraries which have come to rely on the completeness of the Institute's collection. Of the 670 members who borrowed books from the library during the year, 433 were from the Montreal area. The remaining borrowers were distributed as follows: West Coast, 15; Prairies and Western Ontario, 71; Ontario and Quebec, 122; Maritimes, 28; U.S.A., 1.

During the year the library compiled sixty-one bibliographies of periodical articles for members. In addition numerous recommendations of suitable books were made, in letters, over the telephone, and to members visiting the library in person. Eighteen of the bibliographies compiled were in the field of civil engineering, ten electrical and eight mechanical. The remaining twenty-five covered a variety of topics from the "Antartic" to "Wood".

The library handled 319 members' subscriptions to 28 publications of 11 other engineering societies. The library staff also made over 7,000 photoprints, of which nearly 2,000 were sent to members in lieu of bound volumes of periodicals and of otherwise unobtainable papers and articles.

The library distributed over 800 free pamphlets to high school students requesting information on engineering as a career, and over 900 free copies of the Engineering Journal to high school students, undergraduates, and others expressing an interest in the publication.

One new film was acquired during the year, "Blasting a New Niagara". The total film circulation was 63.

Over 600 books were added during the year, bringing the total collection to about 6,300. The value of the volumes received for review in the Engineering Journal was $3,900, and that of those purchased was $800.

The library has exchange arrangements with organizations in thirty countries, including several behind the Iron Curtain, and nearly eighty percent of the 500 periodicals received in the library are acquired on this basis.

It appears that many members are not aware of the full extent of services of the E.I.C. library since most inquiries are largely in the fields of civil and electrical engineering, although the library contains material on all branches, much of which is not available elsewhere.

STATISTICS OF LIBRARY USE

	1957	1958
Mail enquiries	1430	1624
Phone enquiries	3052	3168
Persons visiting the library	2334	2654
Borrowers registered	488	670
Circulation		
Books	1892	2364
Periodicals	1184	1725
Pamphlets	163	237
Total	3239	4326
Parcels of books mailed out-of-town	270	432
Bibliographies compiled	63	61
Photocopies made	3135	7220
Members subscriptions to publications of other societies	338	319
Films circulated	60	63
Books acquired	421	621
Value of books acquired	$ 3723	$ 4747

TABLE II

PHOTOGRAPHIC EXHIBITS

Three exhibitions of photographs were displayed at the annual meeting at Quebec and were made available to the branches and universities across Canada for exhibition. Canadian photographs were submitted in large part by Canadian industrial advertisers in the Engineering Journal. Awards of merit were subsequently presented by the Institute to the exhibitors with the five winning entries. The other two were on the subject "Atoms for Peace", showing development in the peaceful applications of atomic energy in the U.S.A. and in the U.S.S.R. The "Atoms for Peace" exhibits attracted considerable attention, as they were displayed side by side and presented an interesting comparison.

The Canadian photographs submitted for competition at the 1957 annual meeting were shown at six universities in the early months of 1958. "Atoms for Peace" exhibits were shown by eight branches and one provincial association as well as by three Student groups at universities. At the end of the year advance bookings had been made which will keep the exhibits on tour continually until the end of April 1959.

PROFESSIONAL DEVELOPMENT

Engineer's Council for Development
E.I.C. Representation on E.C.P.D. Council

Institute representatives on the Council of E.C.P.D. were Colonel W. S. Wilson, Mr. G. R. Henderson and Doctor Otto Holden. Colonel Wilson's term of office expired during the year and he was reappointed for a three year period. Representatives of the professional development programs of Toronto, Hamilton and Niagara attended the two-day work session of the training committee of E.C.P.D. held in Pittsburgh on May 19th and 20th. The following is quoted from the 1958 Annual Report of E.C.P.D.

> "An excellent discussion of the "Canadian First Five Year's Program — for Young Engineers, by Young Engineers" was given by three young members representing the Professional development program group of the Engineering Institute of Canada. Steps are being taken to have their presentation published".

The Institute was also represented at the 26th Annual Meeting of the Engineers' Council for Professional Development at which representatives from the Toronto, Hamilton and Niagara branches of the Institute presented a similar demonstration to that which was given at the Pittsburgh meeting.

The following definition of engineering, submitted by the Recognition Committee was adopted at the Annual Meeting of E.C.P.D.
It reads as follows:

> "Engineering is the (learned) profession in which a knowledge of the mathematical and natural sciences gained by study, experience and practice, is applied with judgment to develop ways to utilize economically the materials and forces of nature for the progressive well being of mankind".

The following Institute representatives on E.C.P.D. committees were appointed for 1959:

Guidance	— D. A. Young
Education and Accreditation	— C. H. R. Campling
Ethics	— J. E. L. Roy
Recognition	— Guy Savard
Training	— George L. Schneider
Information	— Garnet T. Page
Planning	— L. Austin Wright
Student Development	— E. Muszinski

Preliminary plans were made to hold the 1960 annual meeting of E.C.P.D. in Montreal, early in October 1959.

Professional Development Programs

Following the successful operation of professional development programs in the Southern Ontario region, consideration was given to the formation of a national co-ordinating committee on professional development programs. This committee would provide, through Headquarters, guidance and assistance to branches of the Institute contemplating the establishment of professional development programs.

Professional development programs sponsored by the various branches are included in the branch reports. Sixteen branches planned or were operating professional development programs for the 1958-59 season.

PUBLICATIONS

1958 was the fortieth anniversary of The Engineering Journal and the Institute received many messages of congratulations, including a cordial greeting from the Prime Minister of Canada, on the successful completion of forty years of this outstanding service to Canadian engineers.

Recommenced in the fall of 1957 after over twenty years during which its publication was suspended, "Transactions of the E.I.C." was published on a regular quarterly basis in 1958, providing the sole Canadian medium for the publication of papers dealing with the results of research in engineering. The autumn issue dealing with "Ice" was supplied by special arrangement with the National Research Council of Canada, and has received wide acclaim.

For the second successive year the Institute published its unique "Engineering Careers in Canada", which provided up-to-date vocational information and descriptions of career opportunities to all first and final year engineering students in Canada, as well as to high schools and public libraries.

No historical biographies were published in 1958, but preparations were completed for the publication of an excellent biography of Sir Casimir Gzowski in 1959. The response to the first E.I.C. historical biography "Daylight through the Mountain" published in 1957, continued to be excellent, and further laudatory reviews were received.

In addition, a number of administrative publications, including a branch manual, a student section manual, supplements to the E.I.C. catalogue of films, a manual for councillors, a compendium of data about professional development courses, and several small brochures for students were initiated.

SPEAKERS FOR BRANCHES

In response to requests for assistance from certain branches which normally have some difficulty in arranging for their technical programs, Headquarters gave increased attention to providing speakers who address one or more branches.

In 1958 Headquarters arranged for 34 speakers to address a total of 49 branch meetings.

STUDENT AFFAIRS

As the result of the work of the Student Policy Committee there was increased interest in the formation of student sections. Two new sections were in the process of organization at the end of the year and requests for information and guidance were received from other student groups. Thanks to the efforts of student representatives and faculty advisors, 1310 engineering students jointed the Institute in 1958.

Grants to faculty advisors, amounting to $2250 were made during the year. These grants were authorized by Council to provide financial assistance for student member activities. In addition, grants were made to four branches at university centres for specific projects associated with students activities as authorized by Council.

Over 4,000 copies of the new pamphlet "Serving Canadian Engineers" were distributed at the universities. In addition, copies of "Engineering Careers in Canada, 1958" were distributed to all first year and final year engineering students.

The financial assistance of the Life Members is gratefully acknowledged. They contributed $500 to the Students Conference at Quebec and provided the necessary funds to increase the Student prize to $50.

E.I.C. slide rule tie clips were again presented to all engineering students who became Student members of the Institute.

TECHNICAL OPERATIONS

National

The report of the Committee on Technical Operations on page 22 summarizes the major areas of technical operations for the year. This part of the Institute's program has received a great deal of attention by headquarters, in view of its importance to the membership. In addition to advising on the technical contents of annual and regional meetings, the committee has assisted the Publications Committee considerably, and has aided the staff in their efforts to provide speakers to branches requiring such assistance.

The E.I.C. assists many agencies of government in technical matters and also co-operates with sister societies in Canada in technical activities of major importance. Examples of these are the Committee on Wintertime Construction of the Canadian Construction Association, a number of committees of the Canadian Standards Association, the Canadian Radio Technical Planning Board, and the Canadian Management Council.

International

Participation in the sponsorship of programs of international technical organizations, and their conferences, is an important aspect of the E.I.C. program. In 1958 the Institute took an active part in the Fourth Nuclear Engineering and Science Congress held in Chicago, March 17-21. This congress brings together engineers and scientists of many kinds for the purpose of exchanging new information in the field of nuclear energy. The Fifth Congress was held in Cleveland, Ohio, April 5-10, 1959, and tentative plans are that the Sixth Congress will be held in New York City, in the Spring of 1960.

The Second International Heat Transfer Congress will be held in the U.S.A. and in Europe in 1961. As one of the sponsoring organizations, the E.I.C. is active in the work of the preparatory committee.

Other international technical activities in which the E.I.C. is active include the ASME Committee on Air Pollution, The Column Research Council, The International Association for Bridge and Structural Engineers, the International Aviation Writers Association, The International Federation of Chemical Engineering, The International Electrotechnical Commission, and the Society of Technical Writers and Editors.

Finally, even though the Institute is not itself a member of the World Power Congress, since governments are the only members, numbers of Institute members and headquarter's staff took a leading part in organizing all phases of the sectional meeting held at the Queen Elizabeth Hotel, Montreal, Sept. 7-12. This meeting was attended by 1200 delegates representing 41 nations.

Exchange of Teams of Engineers between Canada and the U.S.S.R.

In January 1958, at the suggestion of the Ambassador of the U.S.S.R. to Canada, and with the approval of the government of Canada and the E.I.C. Council, negotiations were initiated with the object of arranging for exchange visits of teams of engineers between Canada and the USSR.

In June 1958, it became obvious that personal discussions would greatly facilitate the successful conclusion of these negotiations. The government of the USSR invited the President and General Secretary to visit the USSR as its guests while in that country, to discuss arrangements in principle concerning the proposed exchanges and, in addition, inspect typical facilities for engineering education and a number of representative engineering achievements.

The E.I.C. Council at its meeting on July 18th, 1958 authorized the President and General Secretary to accept this invitation, as well as approving the expenses involved in transporting these two officers to and from the USSR.

The President and General Secretary left Canada by air on September 20th and had useful visits with the officers of sister societies in the United Kingdom, Belgium and Denmark as they proceeded east. On September 27th they flew from Copenhagen to Moscow on a Russian jet aircraft, the Tu-104.

On the Monday after arrival, a meeting was held with the vice-chairman and senior staff of the Scientific and Technical Committee, and a program that would best accomplish the purposes of the visit was arranged, after a completely harmonious discussion and mutual agreement. Following this the President and General Secretary spent a strenuous two weeks following the program of engineering, scientific and cultural interests that had been arranged, and in completing the discussions concerning the exchanges of teams of engineers between the two countries.

The President and General Secretary left Moscow by Tu-104 on Saturday, October 11th arriving in Paris later the same day. After paying their respects to the offices of the Institute's sister society in France, they left Paris for North America on Monday, October 13th.

Prior to their departure from Canada, the President and General Secretary had received letters of encouragement and interest from the Secretary of State for External Affairs, Mr. Sidney Smith. Mr. Smith had advised all Canadian embassies concerned about their mission, and the officials at each embassy were most courteous and helpful.

It was agreed that the areas for an initial service of exchange would be petroleum refining, petrochemistry, oil production and drilling, electronics and communications, power stations and the mining and the benefication of ores. Several other areas were considered on a tentative basis.

The delegations are to be small, and the stay in the West countries from three to four weeks. The E.I.C. Headquarters is acting as the clearing house for the Canadian portion of the arrangements, and the Canadian government is kept fully informed.

Conference of Engineering Institutions of the British Commonwealth

This conference, which meets every four years, met from March 19 to April 2 in Sydney, Canberra and Melbourne, Australia. Representatives from Great Britain, South Africa, Ceylon, Pakistan, New Zealand, Australia, and Canada participated. The Canadian delegates were Dr. C. M. Anson, Dr. I. R. Tait and Dr. L. Austin Wright.

A report of the resolutions and recommendations of this Conference were submitted to the Council of the Engineering Institute of Canada in the fall of 1958 and approved. It is anticipated that the next meeting of this Conference will be held in Canada in 1962.

I.A.E.S.T.E.

The E.I.C. continued to act as the Canadian agency for the International Association for the Exchange of Students for Technical Experience. 1958 was the sixth year of such participation.

In January, 1958, Mr. E. C. Luke, Secretary of the Canadian IAESTE Committee and a member of Headquarters' staff, attended the tenth annual meeting of IAESTE in Madrid, Spain.

This was an excellent conference attended by delegates and observers from twenty-one participating nations. He reported that the annual IAESTE exchange involves about 6,000 students, and approximately 35,000 students have been exchanged since the association was formed in 1948. It is certain that this relatively young international movement has become a strong influence toward mutual understanding and goodwill among nations.

From the point of view of total numbers of students accommodated by Canada, 1958 was somewhat of a disappointment. There was an overall decrease of about 12% probably due to general economic conditions in Canada during the year. Many employers who had provided places in previous years were obliged to decline requests for the first time. 95 European students, from 11 countries, were provided with summer employment in Canada.

However, it is encouraging to report that 24 Canadian engineering students took advantage of the plan to visit and work in 10 different countries abroad. This was double the number of Canadian participants in any previous year.

The collection of funds to continue the Canadian IAESTE Travelling Bursaries was difficult in 1958, with the result that the amounts granted to Canadian students had to be rather drastically reduced. At its meeting in October, the Canadian Committee, after considerable thought, decided to discontinue the bursaries on a trial basis for 1959, to test the effect on Canadian participation.

Further useful work was done to foster the general growth of IAESTE in Canada. A strong effort was made to awaken the interest and enlist the future support of other organizations.

It is felt that real progress was made in this direction, particularly with the Canadian Institute of Mining and Metallurgy, the Canadian Metal Mining Association, The Chemical Institute of Canada, and the Canadian Chamber of Commerce. Their kind co-operation is gratefully acknowledged.

V UPADI Congress

The Engineering Institute was host to the V UPADI Congress in Montreal at the Queen Elizabeth Hotel from September 2-6. More than 100 engineers, representing 16 countries in the Western Hemisphere, were present.

Local arrangements for the congress were made by a committee of E.I.C. members, with Dr. I. R. Tait as chairman.

President K. F. Tupper was named President of the Congress, with representatives from Mexico, Brazil, and the United States as vice-presidents. Simultaneous translation in Spanish, Portugese and English was available at all plenary sessions.

In addition to the standing committee meetings, a conference on engineering education was featured. A program of investigation was proposed to establish uniform practices and procedures in engineering education throughout the Western hemisphere.

UNESCO

The Canada Council is the agency of government responsible for UNESCO matters in Canada. It has established a Canadian National Commission for UNESCO, representative of appropriate departments of government and national organization. The Institute is an official co-operating body of the Canadian National Commission for UNESCO, and as such it is consulted on all matters of interest to engineers that are part of Canada's participation in the program of UNESCO. The E.I.C. was represented at the first meeting of the National Commission, held in Ottawa in February.

VOCATIONAL INFORMATION

The vocational guidance activities of the branches, in various forms to suit local conditions, are reported in the annual reports of the branches.

In addition to the great amount of the work done by branches in local secondary schools, the Institute distributed the pamphlets: "After High School What?" and its French language edition "Science Genie", and "Careers in Natural Science and Engineering" published by the Federal Department of Labour. Approximately 1000 pamphlets and sample copies of the Engineering Journal were distributed.

The Institute publication, "Engineering Careers in Canada — 1958-1959" was placed in all Canadian high school libraries, most public libraries, and distributed to all first and final year engineering students at Canadian universities.

WIVES' ORGANIZATIONS

Although not an official activity of the EIC, the Institute attaches great importance to the activities of the engineers wives' associations.

During 1958, the activities of the Engineers Wives' Associations increased all across Canada. The aim of all groups is to welcome newcomers to their centres and to promote cordiality and friendship among the wives of the members of the Institute, and in many cases, among the wives of all members of the profession. Membership figures range from twenty to over three hundred in different cities.

Commencing in 1957, a "Wives' Meeting" has been held at the time of the Annual Meeting of the Institute, at which reports of the groups are presented, and ideas for future activities are exchanged.

Respectfully submitted on behalf of the Council

K. F. Tupper, M.E.I.C.,
President

Garnet T. Page, M.E.I.C.,
General Secretary

THE ENGINEERING INSTITUTE OF CANADA

Statement of Revenue and Expenditure

Year ended December 31, 1958
with comparative figures for 1957

REVENUE

	1958	1957
MEMBERSHIP FEES:		
Annual, including subscriptions to The Engineering Journal	$209,729.84	$204,765.01
Entrance	3,350.50	4,378.50
	213,080.34	209,143.51
PUBLICATIONS:		
Advertising	325,943.43	363,009.94
Sales	6,266.36	5,045.24
	332,209.79	368,055.18
INCOME FROM INVESTMENTS	15,115.47	10,487.10
MISCELLANEOUS	926.32	1,175.06
	$561,331.92	$588,860.85

EXPENDITURE

	1958	1957
ADMINISTRATIVE EXPENSES:		
Salaries	$109,637.33	$ 89,620.27
Travelling	12,931.95	7,069.34
Other	33,513.88	32,075.07
	156,083.16	128,764.68
DIRECT SERVICES:		
Annual and regional meetings	9,526.54	6,921.84
Awards, medals and prizes	698.52	545.97
Branch rebates, stationery, manuals	32,381.09	28,603.66
Certificates for members	241.97	—
Committees — general	781.74	556.63
Council meetings	5,785.54	2,529.48
Unemployment service	8,100.00	7,740.00
Engineering education	1,591.23	8,771.50
International activities	8,367.43	3,017.53
Library	14,551.27	11,926.90
Official reception and hospitality, etc.	3,452.27	3,243.17
Professional development	2,763.48	5,141.04
Publicity and membership promotion	1,149.48	1,714.67
Student affairs	7,200.78	8,497.55
Travelling — president and officers	991.75	1,490.78
	97,583.09	90,700.72
PUBLICATION EXPENSES:		
Salaries	45,226.19	43,955.52
Commissions	82,344.31	91,046.04
Printing and mailing	176,242.70	161,064.46
Other	20,629.25	14,673.40
	324,442.45	310,739.42
BUILDING AND RENTAL EXPENSES		
Headquarters	10,571.28	9,731.46
Toronto office	3,300.00	1,375.00
	13,871.28	11,106.46
EXTRAORDINARY EXPENSES:		
Confederation	3,760.05	—
TOTAL EXPENDITURE	595,740.03	541,311.28
APPROPRIATIONS TO OR (FROM) RESERVES:		
Building	—	30,000.00
Pensions	(2,400.00)	10,000.00
Contingencies	—	4,500.00
Publications	—	1,500.00
	(2,400.00)	46,000.00
BALANCE, SURPLUS OR (DEFICIT) TRANSFERRED TO SURPLUS	(32,008.11)	1,549.57
	$561,331.92	$588,860.85

THE ENGINEERING INSTITUTE OF CANADA

Balance Sheet

December 31, 1958
with comparative figures for 1957

ASSETS

	1958	1957
CURRENT ASSETS:		
Cash	$ 10,492.73	$ 6,615.74
Accounts receivable, less allowance for doubtful accounts	16,302.76	33,809.52
Arrears of membership fees, estimated	6,500.00	6,500.00
	33,295.49	46,925.26
INVESTMENTS, AT COST:		
Securities (market value, 1958 $328,800.00)	341,464.55	362,265.80
Less held for special funds	46,508.31	46,900.21
	294,956.24	315,365.59
FIXED ASSETS AT COST LESS AMOUNTS WRITTEN OFF:		
Land and building	36,000.00	36,000.00
Furnishings and equipment	16,457.23	14,375.17
Library	1.00	1.00
	52,458.23	50,376.17
OTHER ASSETS:		
Sundry advances and deposits	2,612.53	2,320.00
Prepaid insurance	—	646.66
	2,612.53	2,966.66
ASSETS OF SPECIAL FUNDS:		
Equity in investments shown above	46,508.31	46,900.21
	$429,830.80	$462,533.89

LIABILITIES

	1958	1957
CURRENT LIABILITIES:		
Accounts payable	$ 20,558.55	$ 15,342.23
Library deposits	3,802.50	3,802.50
Fees paid in advance, estimated	3,000.00	3,000.00
	27,361.05	22,144.73
OTHER LIABILITIES:		
Life members' fund	7,594.32	5,614.39
Reception and other funds	4,944.58	10,043.91
	12,538.90	15,658.30
RESERVES:		
Building	184,000.00	184,000.00
Building maintenance	1,500.00	1,500.00
Pensions	47,966.50	50,366.50
Contingencies	29,500.00	29,500.00
Publication	26,500.00	26,500.00
	289,466.50	291,866.50
SURPLUS:		
Balance at beginning of year	85,964.15	84,414.58
Surplus or (deficit) for year transferred from statement of revenue and expenditure	(32,008.11)	1,549.57
	53,956.04	85,964.15
SPECIAL FUNDS:		
Balances per statement attached	46,508.31	46,900.21
	$429,830.80	$462,533.89

AUDITORS' REPORT

We have examined the balance sheet of The Engineering Institute of Canada as of December 31, 1958 and the statement of revenue and expenditure for the year ended on that date and have obtained all the information and explanations we have required. Our examination included a general review of the accounting procedures and such tests of accounting records and other supporting evidence as we considered necessary in the circumstances.

In our opinion the accompanying balance sheet and statement of revenue and expenditure are properly drawn up so as to exhibit a true and correct view of the state of the affairs of the Institute at December 31, 1958 and the results of its operations for the year ended on that date, according to the best of our information and the explanations given to us and as shown by the books of the Institute.

PEAT, MARWICK, MITCHELL & CO.,
Chartered Accountants.

MONTREAL, P.Q., MARCH 12, 1959.

TREASURER'S REPORT

As indicated in the report of the Chairman of the Finance Committee, expenditure exceeded revenue during 1958.

Revenue for the year showed a decrease of some $27,000 from 1957 and totalled just over $560,000. Expenditure increased some $54,000 reaching $595,000. There was a draw-down on reserves for pension payments and it was necessary to reduce accumulated surplus by the year's deficit of $32,000. In these circumstances, it was not possible to add to our various reserves during 1958.

Revenues from advertising at $325,943 in 1958 were $37,000 less than in the previous year. Increases in local activity arising from Confederation discussions led to greater direct service expense. At the international level — participation in the Commonwealth Conference of Engineering Societies and exchange discussions with the U.S.S.R., resulted in greater staff travel.

There has been a reduction in assets in 1958 mainly in the accounts receivable and securities investments. At the year's end the Institute's assets, according to the auditors' statements, totalled $429,830 whereas in 1957 they were $462,533.

T. W. EADIE, M.E.I.C.,
Treasurer.

REPORTS OF THE COMMITTEES

ADMISSIONS COMMITTEE

During 1958, the Admissions Committee held nine regular meetings. In all, 424 candidates were considered and 1310 Students were admitted:—

Applications for Corporate Membership	283	
Applications for Affiliate Membership	12	
Special Cases	46	
Applications for transfer	83	
Student admissions	1069	1493
Admissions through Provincial Associations:		
Applications for Corporate Membership	119	
Applications for Transfer	81	
Students	241	441
Total		1934

ROGER BRAIS, M.E.I.C.,
Chairman.

BOARD OF EXAMINERS

The Board of Examiners held three meetings during 1958, during which 26 candidates were considered.

Five candidates were admitted after verifying and assessing their qualifications. Four were accepted as Members and one as a Junior member. Twelve candidates were advised to qualify through the Provincial Associations concerned.

Two were advised to qualify through oral examinations and are still pending.

At the year end seven candidates were still under consideration.

A recommendation was made to Council and approved, concerning recognition of qualifications obtained through British Institutions.

J. L. DE STEIN, M.E.I.C.,
Chairman.

CANADIAN CHAMBER OF COMMERCE

Throughout the year, The Canadian Chamber of Commerce carried out its responsibilities in expressing the views of business on public affairs, in promoting improvements in Canada's trading position, and in promoting the right economic climate for business.

Highlights were the annual meeting, held in Montreal, October 6, 7 and 8, at which the Chamber's policies for 1959 were approved, and the presentation of these policies to the Prime Minister and Cabinet in Ottawa on January 9, 1959.

Following are the Chamber's official views on subjects which are of particular interest to the engineering profession:

A major new policy statement on labour relations holds that unions should register with the Department of Labour and comply with similar conditions, in so far as reporting is concerned, as companies incorporated under the Companies Act. The Government has been told that an amendment making this mandatory should be included in the Industrial Relations and Disputes Investigation Act expected to be up for revision at the forthcoming session of parliament.

The submission suggests that, while good industrial relations cannot be created by legislation, nevertheless to the degree that legislation may be necessary it should be designed to ensure a proper balance of rights and responsibilities of employees on the one hand and of employers on the other, with due regard to the public interest.

Dealing with trade, the Chamber says Canada's trade policy should be designed to encourage the continued development of the country's natural resources and at the same time step up industrialization. While the expansion of trade on a multilateral basis is in the best interests of the country, Canada cannot proceed further or faster in setting the example for freer trade between nations than is justified by the actions of the leading trading nations of the world.

The government is asked to completely revise the Customs Tariff and the Customs Act, which are outmoded, particularly in regard to many so-called "end use" and "class or kind" tariff items.

The Chamber also advocates that some form of financial machinery for longer-term credit facilities be made available to Canadian exporters, including engineering and construction, in order to enable them to be competitive with exporters of other countries who now enjoy such credit facilities.

Chamber policy also points to the need for gradual tax reduction which can only be achieved if spending is contained. The Government is asked to make a re-examination of the entire income tax structure in Canada because personal and corporate income tax rates are too high for a developing country.

Chamber policy also asks that the Government:—

1. Take aggressive action to ensure a greater and more continuous flow of desirable immigrants.

2. Re-examine the Canadian defence programme to ensure that adequate provision is being made for the vastly more expensive weapons of the future.

3. Complete as expeditiously as practicable the review being made of combines control legislation.

4. Recognize with respect to any regulation required at the national government level relating to energy resources that this regulation should be administered by existing agencies of the Government of Canada, augmented where deemed necessary.

5. Take the lead for the immediate establishment of machinery for interprovincial liaison and planning for the construction of interprovincial and other highways of national importance.

6. Give secondary industries in Canada every possible support exclusive of subsidies to encourage the export of finished goods.

7. Permit tenders for the Federal Government and the Crown Companies to be received in regional offices at a date and time that is simultaneous throughout Canada, after which they shall be forwarded to Ottawa to be opened.

F. G. Rutley, M.E.I.C.,
Representative

CANADIAN STANDARDS ASSOCIATION

During the year four meetings of the Board of Directors and sixty-two meetings of Technical Committees were held.

Publications issued during the year included 26 new standards, 4 issues of the "Quarterly Bulletin" and 4 issues of "CSA News". The "Bulletin" includes meeting reports, advice concerning new and current projects and newly issued specifications, while the "CSA News" provides up-to-date information on CSA standardization activities, lists of newly issued specifications and lists of new sustaining members.

The following new standardization projects were authorized by the Board of Directors:—

Hydraulic, electric and pneumatic installations on machine tools, plumbing fixtures, electrical insulation, design specifications for structural aluminum, surface finish of metals, explosion-proof enclosures, skelp, and steel farm fences.

Requests for several additional new projects are now under consideration by the Board.

173 standards reached various stages of development by the end of the year as follows:—

36 — Technical Council (Final authority for technical content)
7 — Sectional Committees.
37 — Specification Committees.
93 — Preliminary Development.

In addition there are revisions to 37 standards in various stages of development.

During the year the Association granted five licences authorizing use of the certification marks, "CSA STANDARD" and "CSA STD" indicating compliance with the provisions and requirements of published CSA Standards.

The CSA Testing Laboratory has equipped its thermal laboratory with the necessary facilities for the purpose of conducting extensive tests on gas appliances, equipment and accessories. The certification service thus provided has been integrated with the oil and electric certification services in order to provide the manufacturer with a complete and unified program for those appliances and equipment which utilize combinations (e.g. oil-gas, oil-electric, gas-electric, etc.) of fuel and energy sources.

The Laboratories have completed a successful year of operations and the number of applications for certification continues to increase.

It is with regret that we announce the passing of P. L. Pratley, M.E.I.C., who served as E.I.C. Representative on Technical Council. A successor had not yet been appointed at the end of the year.

CONFEDERATION

The Institute's committee is pleased to report that the year 1958 saw more progress towards Confederation than has been in evidence previously.

So far the members of the Institute have not been consulted but the councillors have had the opportunity to study the report put out by the Joint Committee and have given their approval of it. Also, the councils of the provincial organizations have approved it. It is expected the membership will be asked for their approval shortly.

The report is based on the eight clauses presented to the Plenary Meeting of Council at Quebec in May. There have been no changes in the basic principles or philosophy, but amplifications and interpretations of the clauses have been made a part of the report. Also, the report contains figures on income and expenditures for the National Body, which are used as the basis of the proposed initial fee for the National Body.

The report also proposes that the membership authorize the creation of an interim council to be known as The Engineers Confederation Commission, which will be charged with the task of drawing up the final agreement and the detailed by-laws and regulations necessary for the operation of the National Body. This Commission will represent both the associations and the Institute branches and will have on it representatives from every province and territory.

The Commission's report will be submitted to each corporate member of the Institute for approval. Similarly, the report will be submitted to the provincial bodies. When approval from the Institute membership and the Associations is received, the Commission will be dissolved and the National Body will take over. At that moment Confederation becomes a reality.

The general purpose of Confederation as proposed in the report is to "enable enlarged services to be rendered to the professional engineers of Canada." This will mean the elimination of overlapping activities, the addition of new interests and activities, the development of efficiency in society management, an increase in public recognition, and a reduction in costs and in individual fees.

Your committee wishes to emphasize the pleasure they have had in working with a similar committee appointed by the Canadian Council of Professional Engineers — together constituting the Joint Committee. In particular this applies to the members of the sub-committee who with their opposite numbers from the provincial groups, constituted the Joint Sub-Committee. These six members met several times throughout the year, in Toronto, Ottawa and Montreal. They have spent long and frequent hours in discussions, in deliberations, in the preparation of documents. At no time were they far apart in their ideas, and at the end of it all they were completely unanimous in their recommendations to their own committee and to the parent bodies.

This of itself was a great achievement and perhaps is the best guarantee that Confederation will accomplish its objectives.

It is almost necessary to take a few items from 1959 in order to adequately appraise the work of 1958. In January 1959, the Institute held a Council meeting at Toronto at which the report of the Joint Committee was considered at great length. This meeting finally passed the following resolution:

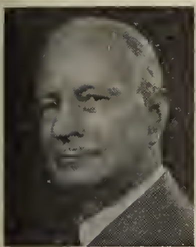
> "That this meeting of the Council of The Engineering Institute of Canada receives and now approves with appreciation the report of its Committee on Confederation (dated 6th November 1958), instructs the General Secretary to circulate to all members of the E.I.C. the ballot suggested in Dr. Tait's letter of January 9, 1959, in a form to be agreed upon by the Joint Committee and by Council, and to request its Committee on Confederation to continue its good work until the proposed provisional Council is appointed."

Since then the report has been revised slightly and once again has been approved unanimously by the members of the Joint Committee. It will be presented to the Council of the Institute in Montreal at the April meeting. After approval there, it is recommended by the committee that it go to the membership with a ballot asking for approval.

Your committee believes that the road to Confederation is now open. As already explained, there are certain steps yet to be taken, but it is not expected they will present any difficulties. When a report similar to this is being written for 1959, it may well record the realization of the long sought objective — Confederation.

Irving R. Tait, Hon. M.E.I.C.,
Chairman.

LIFE MEMBERS COMMITTEE



The number of Life Members within the Institute membership increases each year. The total grew from 751 in 1957 to 809 in 1958; 738 of these are in Canada; 16 in Great Britain and 49 in the United States. There are 7 in other parts of the Commonwealth and 2 are classified as foreign. 45 Life Members died in 1958.

The Life Members Committee again administered the funds collected during the annual appeal. The sum collected from December 1957 to November 1958 was $3,706.00.

Disbursements were made to assist the Institute in several of its activities. For example, $375.00 was made available to augment the Student prizes of the Institute, thereby making the prize $50.00 instead of $25.00 and $500.00 was donated to assist in meeting the expenses of the annual Students Conference held during the course of the annual meeting.

The committee, at its meeting on October 24th, 1958, considered making money available in the form of prizes or bursaries to assist worthy and needy students in meeting their university expenses. Realizing that substantial sums of money would be required to do this on an adequate basis, the committee has been canvassing some of the deans of engineering to get their reactions to proposals which the committee has been considering.

No decision has been reached as yet but favourable comments have been received in every instance. The deans emphasized, however, that as the cost of the university education is increasing steadily it becomes desirable, if not necessary, that the amount of money available should be increased substantially also. It is possible, that with the steady increase of contributions made by the Life Members something worthwhile in this field can soon be done.

The Life Members in the Montreal district had a social evening at Institute Headquarters on April 24th of 1958. It is hoped that a similar event can be arranged for 1959.

L. Austin Wright, Hon. M.E.I.C.
Chairman.

LEGISLATION COMMITTEE

The legislation committee held no meetings, as no matters were referred to it for study or recommendation.

R. B. Winsor, M.E.I.C.,
Chairman.

NOMINATING COMMITTEE 1959

Amherst, R. L. Alexander.
Baie Comeau, T. G. Rust.
Belleville, C. H. Lusk.
Border Cities, C. G. R. Armstrong.
Brockville, R. H. Wallace.
Calgary, A. W. Howard.
Cape Breton, C. N. Murray.
Central British Columbia, E. R. Gayfer.
Chalk River, H. V. Smith.
Corner Brook, K. Bulins.
Cornwall, J. M. Hawkes.
Eastern Townships, J. C. Davidson.
Edmonton, R. N. McManus.
Fredericton, I. M. Beattie.
Halifax, O. N. Mann.
Hamilton, L. C. Sentance.
Huronia, Ross MacKay.
Kingston, D. L. Rigsby.
Kitchener, M. A. Montgomery.
Kootenay, W. G. Small.
Lakehead, E. T. Charnock.
Lethbridge, C. S. Clendening.
London, D. D. C. McGeachy.
Lower St. Lawrence, J. R. Menard.
Moncton, L. R. Wadlyn.
Montreal, C. G. Kingsmill.
Newfoundland, J. P. Henderson.
Niagara Peninsula, C. G. Cline.
Nipissing and Upper Ottawa, T. H. Chapman.
North Eastern Ontario, William Kay.
Northern New Brunswick, R. C. Eddy.
North Nova Scotia, M. C. Wolfe.
North Shore Lower St. Lawrence, M. Storrier.
Ottawa, R. F. Legget.
Peterborough, B. Ottewell.
Port Hope, R. W. McNally.
Prince Edward Island, J. D. M. MacDonald.
Quebec, Paul Vincent.
Saguenay, C. C. Louttit.
Saint John, J. J. Donahue.
St. Maurice Valley, D. M. McKim.
Sarnia, Gordon W. Ames.
Saskatchewan, L. T. Holmes.
Sault Ste. Marie, F. H. MacKay.
Sudbury
Toronto, M. McMurray.
Vancouver, W. O. Scott.
Vancouver Island, Thomas Miard.
Winnipeg, T. E. Storey.
Yukon, J. R. B. Jones.

Chairman: W. K. Gwyer, M.E.I.C., Trail, B.C.

PAPERS COMMITTEES

During 1958, responsibility for the content of the technical program of the Annual General and Professional Meeting was transferred by Council from the Papers Committee to the Committee on Technical Operations.

There having been no other business placed before the Papers Committee, its activities have been restricted to providing all possible assistance to the Committee on Technical Operations during the period of transition.

J. H. Budden, M.E.I.C.,
Chairman

POLICY COMMITTEE

The Policy Committee was established in 1957, to serve as an advisory body to the council. It studies questions of major policy and prepares recommendations to guide council in its actions.

In 1958, this committee took an active interest in the Institute's new program of regional technical meetings, Zone "A" council meetings, the work of the field secretaries, publications, student affairs and annual meeting dates, and conducted a review of special funds now held by the Institute.

A. Deschamps, M.E.I.C.,
Chairman.

PRAIRIE WATER PROBLEMS

Once again this year the Prairie Water Problems Committee did not hold a meeting, but its members watched with interest certain developments in the prairie water problems.

Construction was continued on the Waterton — Belly River diversions. The Saskatchewan and Dominion Governments completed agreements and work was begun on the Outlook development on the South Saskatchewan. Construction work was continued on some of the St. Mary's — Milk River canal system so that more utilization of irrigation was possible.

A committee was formed by the Alberta Government to study the whole aspect of irrigation during the summer of 1958, and their report will undoubtedly have some impact on the future development and plans for development in Alberta.

The committee will continue a watching brief on the development of prairie waters, and hold meetings as necessary.

G. A. Gaherty, M.E.I.C.,
Chairman.

PROFESSIONAL INTERESTS

The activities of this Committee on Professional Interests have been largely suspended as a result of the discussions going on in regard to Confederation.

Any new agreements between the E.I.C. and the Provincial Associations or changes to the existing agreements have been held up until this whole matter is settled or clarified.

This committee has not carried out any other specific duties and stands ready to act when required.

E. B. Jubien, M.E.I.C.,
Chairman

PROPERTY COMMITTEE

The committee held one meeting, on June 30, 1958, at which the President and General Secretary of the Institute were present, with five members of the committee. Last year we reported that a large building might be erected to the north of the Institute premises on Mansfield Street, Montreal. The chairman had several meetings with the prospective owner of this building to the point that dates were discussed of the time an offer would be made for the property of the Institute. As a result of these discussions, it was recommended that a real estate valuation of our property be made on the basis of ascertaining not only the present market value but also the market value of the property in the light of real estate sales of property adjacent to our own. This valuation was made and, while it cost about

$400.00, your committee believed the expenditure necessary if the Institute were to consider an offer of purchase. While the urgency of making a decision has lapsed, the owners of the property to the north are still asking the Institute to place a price on our Mansfield Street property.

Several months ago the committee consulted two of the leading real estate agencies in Montreal, asking them if they knew of, or could locate, other premises which would be more suitable. So far neither one has made a satisfactory proposal.

There are several possible recommendations that your committee might eventually make. It must be pointed out, however, that the present location is an excellent one and that the Institute is presently occupying extremely low-cost space.

For immediate attention your committee recommend that, in order to overcome the present shabby appearance and serious overcrowding, the following steps be taken during the summer of 1959:

1. The Montreal Branch be requested to relinquish the auditorium and to rent meeting space in one of the many excellent assembly rooms available in Montreal. The branch now pay extra dues to the Institute for the use of the auditorium, and certain other services. Some of this revenue could be diverted to meet the extra cost to the branch.

2. The auditorium be turned into office space after proper plans and specifications have been approved.

The committee would like to point out that they consider the Headquarters building in its present form and condition to be inadequate for a professional body of the standing of The Engineering Institute of Canada. Any monies spent now to make the building adequate for present requirements may be only a temporary measure and, in making such expenditures, the future should be kept in mind.

F. G. Rutley, M.E.I.C.
Chairman,

PUBLICATIONS COMMITTEE

This committee acts in an advisory capacity to the editor on the general policy of the publications of the Institute, and makes recommendations and reports to Council on this work.

Five meetings were held during 1958, 100 technical papers were considered, and 55 were approved for publication.

The report on "The Engineering Journal" activities is best summarized by the following tabulation:

Item	1958	1957	1956
1. No. of copies printed	233,950	222,650	207,000
2. Average monthly circulation	19,034	18,106	16,909
3. Average number of pages	184	206	197
4. Average pages of editorial	91	103	100
5. Number of abstracts printed	40	107	———
6. Percentage return on readership survey	40	42	40
7. Percent technical papers of editorial content	36	34	———

Papers published during the year covered the branches of chemical, civil, electrical, mechanical and mining, and included special articles on engineering, ethics and engineering management topics.

This is the order of readership interest, as indicated by the sample readership surveys:

1. Technical papers.
2. Canadian developments.
3. Business and industrial briefs.
4. Abstracts.
5. Employment.
6. Personals.
7. Branch and Association News.
8. Library Notes.
9. Month-to-Month.

An author's page and a section on International News were added during the year.

The publication of Transactions of the Institute was actively pursued during 1958. Four issues totalling 183 pages were printed in total quantity of 54,000 at an average cost of $4500.00 per issue. The purpose of Transactions is to bring to the members papers by Canadian authors which would not otherwise be suitable for publication because of length, limited interest or technical complexity.

The publication has been well received since printing was resumed in September 1957, and is providing a much needed service for Canadian research and development, with resulting enhanced prestige for the Institute.

Comments and suggestions about Transactions are welcomed, and those engaged in the newer and more specialized branches of engineering are particularly invited to contribute articles and to participate in discussions.

The 1958-1959 issue of "Engineering Careers in Canada" was released in November. 12,500 copies were printed, and the majority have been distributed to universities, libraries, engineering societies, high-schools etc. As in the past, this activity is self-supporting.

Close liaison was maintained with the Committee on Technical Operations. This committee is most appreciative of the co-operation extended by CTO and particularly for their assistance in revising and up-dating the list of reviewers, which now includes over 100 authorities in various fields of engineering.

In view of the highly technical content of Transactions, consideration is being given to the formation of a special Editorial Review Board for this publication.

The committee wishes to express its sincere appreciation and thanks to all authors, correspondents, advertisers and members of headquarters staff.

H. A. Mullins, M.E.I.C.,
Chairman

STUDENT POLICY COMMITTEE

Since its inauguration, the Student Policy Committee has been endeavouring to ascertain how the Engineering Institute of Canada may best serve the undergraduate engineer.

Informal discussions with Faculty Advisers at several universities disclosed that protocol, rules and regulations vary considerably among the universities and this influences to a considerable degree the perogatives and scope allowed to a Student Section on each campus.

At the Annual Meeting in Quebec City, twenty student delegates from fourteen degree-granting universities attended a Student Conference where the Society's role in the student's education and career was outlined and considered. The enthusiasm of the delegates and their serious concern over the problems discussed were most encouraging and impressive.

Since the conference the Committee has been working with the Director of Membership Services in the preparation of literature to acquaint the student with the history of the Institute and a student section manual (not yet completed) that will serve as a guide for the organization of a section and the planning of a worthwhile program.

To date the Committee has largely functioned as a fact finding agency but it is now preparing recommendations for Council's consideration. It is our hope that through the suggested program, we will be able to stimulate the undergraduate's interest and enthusiasm while performing the services that he requires and expects from a national professional society.

C. G. Southmayd, M.E.I.C.,
Chairman.

TECHNICAL OPERATIONS

During the administrative year 1958-59, the Committee on Technical Operations was actively engaged in developing procedures, investigating possibilities for enhanced technical activities throughout the Institute, and planning the program for the 1959 Annual Meeting. The Committee met three times during the year. Much of the work was carried out by correspondence, although frequent resort was made to personal contact and telephone.

The six original Divisions (Chemical, Civil, Electrical, Hydroelectric, Mechanical and Mining Engineering) were active throughout the year. Committee and Division personnel totalled some 60 members of the Institute.

Council has approved the formation of a Management Division and a Bridge and Structural Engineering Division.

During the course of the year the guidance provided for authors of papers at Annual Meetings was extensively revised, to give effect to numerous suggestions arising from observations at such meetings. Significant deadlines were also materially advanced, to provide for:—

Receipt of title of paper and name of author or authors	October 31st
Receipt of abstract of paper	November 30th
Receipt of manuscript	January 31st

As of December 31st, 1958 about two-thirds of the abstracts had been received, for the 46 papers being submitted for consideration for Annual Meeting use. These cover all fields of engineering activity in Canada, although many are tied in directly or indirectly with the Seaway.

In addition it is planned to have a panel of five noted Canadian economists, educationalists and engineers discuss "The Economic Impact of the Seaway".

A questionnaire was submitted to the Branches, relative to their interest in the establishment of Branch Technical Discussion Groups informally organized to read and discuss papers presented elsewhere, and made available through Headquarters. Such papers might be selected from among those accepted for use in The Engineering Journal, or Transactions, publication of which would be delayed for an agreed period to allow of such discussion Groups. Any formal technical discussion arising from such reading would be co-ordinated and forwarded to Headquarters for reply by the author and, possibly, eventual publication in the "Journal". The response to this questionnaire has not yet been analyzed.

A number of proposals received by Headquarters for co-operation of one type or another with various international engineering organizations were submitted to the Committee for investigation. Advice was tendered in all such cases. In two cases, proposals were laid before Council for positive action. These were approved by Council, as noted. Assistance was given the Publications Committee in revision of the lists of reviewers.

Respectfully submitted on behalf of the Committee on Technical Operations.

F. L. Lawton, M.E.I.C.,
Chairman

REPORT OF TRUSTEES ON THE HARRY F. BENNETT EDUCATION FUND

Having been appointed Chairman of the Harry F. Bennett Education Fund October, 1958, it is with some diffidence that I undertake this report on the activities of this Fund for the calendar year of 1958.

Many applications for loans were received coming from most of the provinces. Of these, 57 loans were granted for a total of $11,750.00, repayments on outstanding loans were received in the sum of $4,164.50 and interest on the loans of $187.74 was also received.

The Fund had a cash balance of $570.51 as of January 1, 1958 and a cash balance of $1,828.11 as of December 31, 1958.

As on November 25, 1958 there were outstanding balances on loans of $26,906.50. While most of these loans were reasonably recent transactions, there were a number that had been unpaid for several years. It was the opinion of the Trustee that definite steps should be taken to collect these. Accordingly, appropriate registered letters are being sent to these borrowers.

The Trustees feel that more precise rules of procedure should be followed in both making and collecting loans and accordingly Procedures were agreed upon and respectfully submitted to Council.

O. Holden, M.E.I.C.

REPORTS OF THE BRANCHES

AMHERST: 1958 activities began February 3rd with a dinner meeting at the Fort Cumberland Hotel. The speaker was Lt/Col. M. C. Sutherland-Brown, D.S.O., C.D., B.Sc., P.Eng., M.E.I.C., speaking on the Alaska Highway and the Collapse of the Peace River Bridge. As former senior highway engineer with D.W.D., Lt/Col. Sutherland-Brown gave a very informative and interesting talk, well illustrated with slides and movies, including the actual collapse of the Bridge.

On February 17th a joint meeting was held with the Moncton Branch, in Moncton, N.B. The speaker was the Rev. Father M. W. Burke-Gaffney, P.Eng., of Saint Mary's University, speaking on "Sputniks".

On March 17th a counselling night was sponsored at Mount Allison University in Sackville, N.B., for the engineering students and each branch of engineering was explained by the panel comprised of qualified members.

The panel was chaired by H.W.L. Doane, Vice-President Atlantic Zone, E.I.C.

On November 7th, Mr. J. A. McLaren, Eastern Field Secretary, E.I.C. visited the branch and a dinner meeting was held. Mr. McLaren showed two very interesting films "The Blasting of Ripple Rock" and "Building Methods in the Artic".

At a Dinner Meeting on December 5th the election of officers took place and Mr. J. D. Conlon, Chief Engineer, Maritime Marshlands Rehabilitation Association, spoke on the study undertaken by his office on the proposed Tidal Power Project which was considered for incorporation in the Annapolis River Dam now under construction to reclaim marshland in the Annapolis Area of Nova Scotia.

Counselling was carried out by members at Career Guidance Nights at several High Schools in the area.

BAIE COMEAU: As our branch is new, we did not organize any Professional Development Courses last year, nor did we participate in Counselling in Schools.

We have been quite active the last two months investigating the general situation at Baie Comeau. Conditions here are quite different from branches in or near urban centres. We met with our secretary, Mr. L. A. G. Tellier, and discussed the general problem of building an appropriate organization.

We have no *Engineers' Wives' Association* at Baie Comeau. We are interested in such an organization, however, and will discuss it at the next meeting of the Executive Committee.

The branch is attempting to search out methods by which member engineers can help young students to enter the engineering profession.

BELLEVILLE: The account of the activities of the Belleville Branch during 1958 are as follows:

Eight meetings were held during the year including two plant tours. Meeting topics were "Health Problems in Industry", "Water Pollution and Sewage Disposal", "Development of the Industry and Industrial Research in the Uses of Plywood", "The Dock at Baie Comeau" and "The Dew Line".

Tours were made of the Pyrotenax and the Hinde and Dauch Paper plants in Trenton.

$25.00 prizes were given to the Grade XIII student in each of the local high schools who plan to enter engineering and has obtained the highest standing in English, Algebra, Trigonometry, Geometry, Physics and Chemistry. The award was broadened this year to allow a separate prize to be given at each school. David James and Jim Green were the winners at Belleville C.I.V.S. and Quinte Secondary School respectively.

The branch did not hold a Professional Development Course during 1958.

BORDER CITIES: Nine meetings were held by the branch during the year, of which two were joint meetings with the APEO. The program was interesting and varied and was well accepted by those attending. Discussion on the subject of professional development has led the branch to the conclusion that there is no need in the immediate future due to the proximity of Assumption College and other universities located in Detroit.

The branch has advised local schools of their willingness to participate in counciling services if required but there is no organized student guidance program.

The Engineering Wives Association held two general meetings during the year. The Annual Spring Tea was held at the home of Mrs. J. E. Mainwaring of April 12th and on April 29th members enjoyed a tour of the Canadian Rock Salt Plant at Ojibway. Other activities included a family picnic at Point Pelee on June 21st and a luncheon at the Lakewood Golf Club on Sept. 16th.

During the President's visit an afternoon tea was held in honour of Mrs. Tupper at the home of Mrs. C. M. Armstrong with members of the executive attending. Among the groups which are progressing very favourably are three bridge groups and a bowling group. The membership totals approximately 81 and averages an attendance at meetings of approximately half the membership.

BROCKVILLE: Seven meetings and one plant tour were held in 1958. The topics of the meetings covered such subjects as Responsibilities of Management, Engineering Aspects of Fire Underwriting, Pros and Cons of Automation, The Acoustics of the Shakespearean Theatre Stratford, Pitting Corrosion, Water Supply and Sewage Disposal Problems at Brockville, and Laying a Submarine Cable in Lake Maracaibo, Venezuela. Great difficulty was encountered in selecting dates for meetings that would not conflict with the arrangements made by the P.D. group. On occasion it was felt that both Branch and P.D. meetings would suffer unduly from having too many engineering meetings, and as a result joint meetings were proposed and branch attendance at two of the P.D. meetings has proved successful. The average attendance at meetings was 35.

The 1958-59 P.D. course is a series of 10 lectures on general aspects of law. The speakers are from the Law Faculty of Queen's University. The course has proved very popular, and there is an enrollment of 57 of which 30 are non-members of EIC.

The topics of the lectures are Buying on Credit, Criminal Law, Criminal Procedure, Wills and Estate Planning, The Courts and Litigation, Motor Vehicle Accidents, Companies, The Proposed Bill of Rights, Family Laws, and Real Estate Transactions. The average attendance has been 45. The Professional Development Committee feel that the success of this course will form a good basis for future courses with regard to organization, cost and planning. This is the third year the branch has had a professional development course.

A membership drive was held during the year and although considerable effort was put into it, the results were not too encouraging. There is a potential of 93 new members in the area but the results of correspondence and personal approach to these engineers is not yet apparent.

CALGARY: Four general technical meetings were held during 1958. All were of the "double" dinner type, starting at 5.30 p.m. with a very short business meeting and then the first speaker. The meeting would then adjourn for dinner. At approximately 8.00 p.m. the meeting would reconvene and a second speaker give a talk. The average attendance at these four meetings was approximately 85. The branch annual meeting, which is held in April, had Dr. O. M. Solandt, one of Canada's leading scientists as guest speaker and approximately 70 people attended.

The social functions of the year included the barbecue held for President Anson during his visit in January, the annual "Slide Rule Soiree" in February attended by approximately 320 people and the annual barbecue held in September.

The first part of the year saw completion of our first fully fledged Professional development course. The final eight meetings of the 15-meeting course were held in January through to April with approximately 350 members registered. Two courses, one on "Religious Philosophies" and the other on "Government" were held in the fall. Each course consisted of 5 lectures and had a registration of approximately 70 people.

The Student Guidance Committee worked with the General Guidance Committee of the Calgary School Board in providing counselling to high school students. An Engineers' Panel was provided for a student guidance meeting in March. The branch also provided refreshments for the students. Approximately 40 students attended the meeting.

The Engineers' Wives, with a membership of 225, again had a very active year. They had a Handicraft Group, three Bridge Groups and a Cultural "Coste House" Group. The general functions included a Pot Luck Supper, Annual Dinner and The Annual Membership Tea. The wives also made their Annual Scholarship award of $100.00 to a high school student who registered as a first year engineering student at the University of Alberta.

CAPE BRETON: During the year members received talks on "Metropolitan Surveys" "Coal Preparation", "An Engineer Looks at Space Travel" "Lubrication in the Operation of an Oil Refinery" and "A Visit to Australia". Average attendance at these meetings was approximately 35 to 40. On June 11th the annual lobster party was held at Alex LeDrew's summer cottage and on October 31st the Cape Breton branch executive members met Mr. J. A. McLaren, Eastern Field Secretary, for discussions on various phases of EIC activity. A social evening was held on November 17th for members, their wives and friends with an attendance of approximately 45 couples. Reports by the various committee chairmen and by the branch chairman, J. V. Palmer, were delivered at the annual Business Meeting on December 10th and the scrutineers reported the names of the branch officers elected for 1959.

The final event of the year was the highly successful New Years' Eve party attended by more than 100 couples.

The Professional Engineers' Wives Association was formed in 1957 to promote friendship among the wives and widows of the engineering profession. Five business meetings were held during the year with an average attendance of 20 from a total membership of 32. During the year a very successful tea was held at the home of Mrs. W. R. Lewis. Many of the members participated actively in the Mental Health Blitz.

CENTRAL BRITISH COLUMBIA: I am pleased to be able to report that in 1958 our membership has risen by nearly 15% over that of last year. This has been a continuation of the trend for the past few years and is, I hope, a measure of the growing importance of our branch in British Columbia.

Our Central British Columbia Branch covers a very large geographical area and it is, I feel, a credit to our members that attendance at the meetings have been so good and enthusiasm for our projects so high.

During 1958, British Columbia Centennial Year, the branch has brought close to completion the ideas promoted last year of honouring those engineers in British Columbia whose lives and endeavours have done so much to build this province as we know it today. Cairns commemorating them have been placed in a number of leading centres in the central interior.

A number of very interesting meetings were held during the year, in particular that which our President, Mr. C. M. Anson and wife attended. It was a great pleasure to have our President in attendance and I am sure his visit was very much appreciated.

I should like to extend my sincere thanks to the 1958 Executive, especially our secretaries and convenors who have done splendid work in arranging the meetings of the Institute during the year and carrying out those duties which befell them. I would like further to extend my good wishes to the incoming 1959 Chairman and executive and hope that our membership will give them the splendid co-operation which I have experienced in 1958.

CHALK RIVER: The Chalk River branch was inaugurated on May 9th, 1958 with a nominal role of 31 members. The boundaries of the Chalk River branch as approved by Council consists basically of the County of Renfrew less the Townships of McNab, Bagot, Blithfield, Admaston Horton and Ross.

Meetings were held on November 19th and December 17th at which interesting talks on the Chalk River Project were heard and a film entitled "Our Mr. Sun" was shown. During the year the Chalk River branch was host to the Nipissing and Upper Ottawa branches and the Peterborough branch and supplied guides for a tour of the plant. The Chalk River branch would be pleased to arrange and conduct visits to the Chalk River Plant A.E.C.L. at any time. Any branches interested in this tour please contact the branch secretary giving one month's notice if possible.

The branch is not yet engaged in student counselling activities nor has it encouraged the formation of an Engineers' Wives Association. In regard to the latter activity it is considered more advantageous to encourage members and wives meetings than to attempt to form another group, since there are many clubs and societies already operating in the Deep River area.

CORNER BROOK: Five technical meetings, one dinner meeting and two business meetings were held during the year. Subjects covered during the technical meetings were "The Application of Air to Industry", "Communications with Emphasis on Trans-Canada Toll Dialing Systems", "The Microwave System", "An Engineer Looks at Space Travel" "Wild Life in Newfoundland".

On June 27th, a dinner meeting was held at which Mr. W. S. Read spoke on "The Watson's Brook Power Development". A business meeting was held on January 28th and on November 6th, an executive dinner meeting was held with the visiting Field Secretary, Mr. J. A. McLaren. Attendance at all meetings was generally good varying from 12 to 25 members.

In general the Corner Brook Branch enjoyed a very good year in 1958.

CORNWALL: During the year 1958 our activities were maintained at the same high level as in previous years. We started off with a visit from our Montreal Vice-President Mr. Deschamps. The ladies were present and the two recipients of our bursary were presented with certificates at this time. The other meetings during the year were of varied interest with talks on the following:

- "Economic Advantages of Complete Year Round Air Conditioning"
  by Mr. N. K. Smith of Honeywell Controls.
- "Charting Arctic Waterways"
  by Mr. Mike Bolton of Canada's Hydrographic Services.
- "Conversion of Coal Fired Boilers to Oil"
  by Mr. G. Van Beek.

A visit to the Power Dam closed our season for the summer.

The Fall season opened in October with a talk on the "Modification of the Jacques Cartier Bridge" by Mr. Ross Chamberlain and in November Mr. Serge Stuken of Canadian Arsenals talked on the production of Ballistic Missiles. It will be seen that the topics were of a more general interest rather than purely technical. This is in many ways dictated by the rather varied interest of the engineers in our branch. Attendance at all talks was an average of 25 members.

Our membership has fallen off during the past year and many friends we had made during the construction of the Hydro Project have left.

No award of the Magwood Bursary was made this year because in the eyes of the bursary committee no student was eligible. All students who were previous recipients are doing well at their respective universities.

On April 2nd the Cornwall Collegiate and Vocational School held a career day programme. Members of our group addressed groups of students on mechanical, electrical and civil engineering.

EASTERN TOWNSHIPS: The branch held eight meetings during 1958. Most of these meetings were held at Le Club Social de Sherbrooke, and included a buffet supper sponsored by local commercial or industrial firms. Attendance at meetings was relatively high.

On January 10, Mr. R. L. Beck, engineer of the Civilian Atomic Power Dept., Canadian General Electric gave a talk entitled "Progress in Atomic Energy", illustrated with slides. Members of C.I.M.M. Sherbrooke Branch were our guests. J. S. Mitchell & Co., sponsored a buffet supper served before the meeting to almost 110 members and guests.

Mr. C. A. Peachy, President of the Corporation of Professional Engineers of Quebec addressed a joint meeting E.I.C. — C.P.E.Q. in February. A total of 121 engineers turned out to hear Mr. Peachey's "Plan for Unity", and enjoyed a splendid buffet-supper offered by Codere Ltée.

The first students' night organized for engineering students at University of Sherbrooke was held at the auditorium of the Faculty of Engineering on March 14th. Mr. Adrien Leroux, fourth year student won the first prize with a paper entitled "Power Factor Correction". At the end of the meeting, lunch was served at the Cafeteria, courtesy of Coté, Lemieux, Carignan & Bourque, Consulting Engineers.

On April 11th, C.I.M.M. Sherbrooke Branch invited members of the branch to a meeting sponsored by Forano Ltd. and featuring Mr. R. F. Shaw, Vice-President of Foundation Co. of Canada. Mr. Shaw gave a talk on the "Dew Line", illustrated with an excellent film in colour.

The annual meeting of the branch was held at Beauharnois, Que. on May 3rd on the occasion of a visit of Beauharnois Power Development and the adjoining Seaway Locks.

The Annual Golf Tournament took place at the Sherbrooke Country Club on September 27th. In spite of very inclement weather, 37 members participated. Mr. Roland Dugre from Asbestos, Quebec won the Fabi Trophy.

Mr. F. T. Matthias, Director of Engineering and Construction Division, Aluminum Co. of Canada, addressed a joint meeting E.I.C. — C.I.M.M. on Alcan's "Chute-des-Passes" Power Development. This meeting had been arranged by the Sherbrooke Branch of C.I.M.M. and sponsored by Hall Machinery of Canada Ltd. At the end of last year, the branch reached an agreement with C.I.M.M. Sherbrooke Branch whereby two meetings of the season would be joint meetings, and each of the branches would organize one meeting. This agreement was made in order to help the local branch of C.I.M.M. which has lost a few members following the closure of mining concerns in the Eastern Townships.

Finally a joint meeting C.P.E.Q. — E.I.C. was held on December 12th to honour Mr. Guillaume Piette, President of the Corporation. On this occasion, the president inaugurated the Eastern Townships Chapter of the Corporation. The officers of the new chapter are those of the executive committee of the branch.

EDMONTON: The Edmonton Branch held seven dinner meetings during 1958 with an average attendance of 80. A variety of speakers were heard at these meetings, their subjects ranging from nuclear power stations to development of Canada's north.

One field trip to the Premier Steel Plant on the outskirts of Edmonton was made in March.

One lecture meeting was held, the subject being the "Deas Island Tunnel". This talk was given by Mr. Lea of the Foundation Co. of Canada and was arranged by the Western Field Secretary.

The two highlights of the year were the annual family picnic, held in June, and the annual dance, held in November. Both of these functions were well attended.

A professional development program was begun in the Fall of 1958 and was offered in association with the department of extension of the University of Alberta. The detailed arrangements for this course were made by Mr. Jack Longworth, chairman of the Young Engineers' Committee, in co-operation with officials of the department of extension.

The program was divided into two parts. Three lectures on "Effective Reading" and two on "Public Speaking" were presented during October 20th to December 15th. The lectures were of one and one-half hours' duration and were held every second week. Five lectures on "Business Management" were planned and these commenced on January 12, 1959. The fee for the total series was ten dollars, or five dollars for each half. 64 members were enrolled for the first half of the program and 55 for the second half.

This branch did not carry out counselling in high schools in 1958.

The Engineers Wives' Club was again very active during 1958. 1958-1959 is the tenth season during which this Club has been in existence. A monthly meeting is held each month from September to April. As well as these monthly meetings, the following activities are carried out by smaller groups within the Club: Books, Bowling, Curling, Bridge, Handicrafts, Dancing and Public Speaking.

The membership at the end of 1958 was 353.

FREDERICTON: During the year the branch held eleven regular meetings most of which were dinner meetings with guest speakers.

A total of seven speakers and one panel discussion were heard on such varied subjects as:

1) Hydrology of the Saint John River.
2) The Organization and Operation of a City Engineers Department.
3) The Human Side of Engineering.
4) The New Steam Generating Station of Fraser Companies Ltd. in Edmundston, N.B.
5) Prospects for Thermal and Nuclear Power Generation in the Future.
6) Past and Future Developments in the Telephone Industry.
7) Problems of Water Pollution and its Control.
8) The Status of Confederation of the E.I.C. and Professional Engineering Organizations.

Of the seven speakers hear, five were from outside the Fredericton Branch and were:

Mr. A. H. Tweedie of the Royal Canadian Engineers.

Mr. T. Bellinger of H. C. Acres & Co. Ltd.

Mr. J. Cunningham of the N.B. Telephone Company.

Sir Claude Gibb of C. A. Parson's Co. Ltd., England.

Mr. D. O. Turnbull, Consulting Engineer.

The two branch members who delivered papers were Mr. J. L. Feeney and Mr. W. L. Barrett.

Social entertainment included a dance sponsored by the U.N.B. Engineering Society, a smoker for the graduating engineers at U.N.B. a lobster boil in June and the upriver meeting at Edmundston in September which included a dinner, dance and golf tournament.

This latter function, which combined social and technical functions was organized completely by the non-resident members and was a great success.

The ladies were invited to all the social functions with the exception of the student smoker.

HALIFAX: Membership in the Halifax branch increased by 42 and totalled 598 by the end of 1958.

The technical and social program for the year was a most successful one. Ten general meetings were held, in addition to a very successful showing of the pictorial exhibit "Atoms for Peace in the USSR". The two social events of the season were co-operative efforts with the Association of Professional Engineers of Nova Scotia and took the form of a joint Annual Banquet and a special meeting at The Pines in Digby.

The technical meetings were generally well attended with the notable exception being the February meeting with senior students at Tech.

For the first time in a number of years the branch closed the books showing black ink. This was done without prejudice to the general activities of the Halifax branch and as a tribute to the enthusiasm and support of the members.

It was necessary to appoint two new members to the executive during the year. In accordance with the requirements of the by-laws, Mr. R. B. Killam of Yarmouth replaced Mr. J. E. Clarke who was transferred from the branch area, and Mr. H. A. Marshall replaced Mr. W. J. Phillips who was elected Vice-Chairman at last year's election.

Headquarters this year emphasized the advantages of the formation of technical divisions in the various branches. After considerable discussion your executive decided and so advised headquarters that technical divisions would not be successful in our organization at this time. However it is gratifying to note that a number of Halifax branch members are on the National Committee on Technical Operations.

Careful consideration was given to the organization of professional development courses in the branch but after much discussion it was decided that professional development courses would not be organized in 1958. An opinion was expressed that the universities, The Junior Board of Trade and various private companies offered somewhat similar courses, and that the need was not as great as in previous years.

The branch was active in student affairs and is now ready to provide student guidance services to advance pupils at high-schools in the area.

The Halifax branch participated actively in the Maritime Professional Engineers' Conference at Digby and enthusiastically supports this worthwhile activity.

HAMILTON: The total membership at the year end was 471 members, a decrease of 31 from the previous year. There was a decrease in all categories except Branch Affiliates.

Hamilton Professional Development Program continues the success it has enjoyed for several years under capable leadership. The Director attended meetings of the Engineers' Council for Professional Development in Pittsburgh and St. Louis and, together with representatives from Toronto and Niagara Falls, outlined the programs being conducted in Canada. The program has a membership of approximately 150. A self-appraisal form is being prepared to assist members in determining their progress since graduation. A comprehensive reading list has been provided to the membership.

A varied and interesting program at eight meetings was held during the year, and included a field trip to the Parkdale Works of the Steel Co. of Canada. To change the format of the fall stag, a beer and oyster party was held in September on McNally's farm near Waterdown. This was a very successful occasion in spite of the beer strike. The Annual Engineers' Ball was attended by 140 couples and was one of the best balls we have had. The die casting section of the Canadian Manufacturers' Association provided an interesting panel discussion together with a film of the Die Casting Industry. President K. F. Tupper visited the Branch in November and addressed the membership on his trip to Russia . . . The 5:30 Dinner meeting appears to be gaining favor in many Branches. The program committees are commended for providing varied and interesting meetings.

The branch news editor provided coverage of all branch functions in both the Hamilton Spectator and the Engineering Journal.

The meeting attendance varied between 40 and 75. The efforts of the attendance committee are directed to the new members of the Branch through a phone squad.

Two very successful programs have been operated in the past two years. A course on the general subject of Law is presently being conducted by members of the Hamilton legal profession. 126 are registered of whom 59 are non-E.I.C. members. Interest is very high in this course.

The counselling committee maintained by the Branch has filled several speaking assignments. Members have been asked to assist in counselling McMaster engineering students. This program can have beneficial results to all concerned when in operation.

The first conference of a regional nature was held in Hamilton this year. Its success is now a well-known fact. 200 couples attended from all of Southern Ontario. The calibre of the technical papers was high. An interesting program was provided for the ladies. Many branches have inquired about the program to guide them in preparing their own conference.

We express sincere appreciation to all those who have been responsible for providing the many services rendered by the Branch in the furtherance of the engineering profession. Your work on the various committees is gratefully acknowledged.

HURONIA: The Huronia Branch enjoyed a fairly active year. The subject matter of our meetings was well diversified and maintained considerable interest among the members.

Counselling of high school students was carried out by a committee appointed for this purpose. This committee worked with members of the Canadian Institute of Mining and Metallurgy and extended their service to outlying areas of the branch through Institute members.

The desire to establish a professional development course has not yet been noted. It seems that the lack of a concentration of junior members in any one town of our area has hindered any movement in this direction.

KINGSTON: The program for the year was an active one beginning on January 14th with a paper on "A Ship Model Milling Machine" and finishing on December 9th with a ladies film night. In the intervening period the branch was presented with papers on "Vibration Problems in a Large Utility", "Air Pollution in Hamilton, Ontario", "Water Resources" "Some Aspects of Racing Yacht Design" and "Modern Instrumentation in Control of Chemical Processes". An informative and interesting panel discussion on engineering education moderated by L. F. Grant and consisting of D. M. Jemmett, D. L. Rigsby, V. S. Ready and R. W. T. Birchard was held on February 6th. A student paper's night was held on March 4th and the Joint CIC, KMS, EIC Dance took place on March 7th. The annual meeting and dinner was held on May 31st. The branch did not operate a professional development course during the year but some preliminary plans were made for a technical conference to be held early in 1960.

While the branch did no formal counselling during the year a panel discussion on engineering education served its purpose to some extent.

KITCHENER: The Kitchener branch was very active during the year, and thanks to a drive by the chairman and other members of the committee to ensure good turnouts at meetings, the season ended with a slight surplus. A very successful Students Night was held at Waterloo College.

The branch was successful in securing the services of Dr. Lord as the guest speaker and the good results obtained encouraged us to embark on a similar program with the Ontario Agricultural College next year. The program might be stimulated by instituting prizes for student papers or some other similar activity.

The branch continued to provide counselling services for high-school students in the area.

It has been found very difficult to arrange general meetings without coming into conflict with meetings of other local service clubs, and probably because of this, technical meetings are generally not well attended. On the other hand, social functions have been very successful.

It has been the experience of this branch that to ensure successful turn-out a great deal of spade work must be done. Speakers topics should be of a general and interesting nature and some device such as a telephone committee must be used to stimulate interest.

KOOTENAY: The executive has taken a great interest in the national affairs of the Institute this year, stimulated by the close approach to Confederation and also by the progress shown in the development of Zone Council Meetings under the leadership of our member and Vice-President, the late S. C. Montgomery, and by the Western Regional Conference to be held in Banff in 1959.

The Annual Meeting in Quebec City was attended by our councillor and late vice-president, distance preventing other members from participating.

Locally, we have continued to hold regular monthly dinner meetings with the exception of October and November. The meetings, continue to be well attended and appreciated.

We had a total of 7 dinner meetings, 1 smoker, 8 executive meetings and in addition we displayed the Russian and U.S. Panels on Atoms for Peace at a meeting of the Joint Technical Societies in this area.

The highlight of the year was our President's visit in April.

Our Scholarship Award of $50.00 was presented this year to engineering student Grant John of Trail.

We again participated in the Joint Technical Societies' program of vocational guidance for High School Students.

No professional development course was offered in 1958, although preliminary steps were discussed at our last executive meeting toward re-establishment of this course.

Membership has shown a slight decline since the year end of 1957. This is mainly due to deaths, transfer and one resignation.

LAKEHEAD: The Lakehead Branch enjoyed a successful year financially and more important still, the general membership showed a greater interest in the affairs of the branch.

A total of ten meetings were held during the year, two of which were social. The technical meetings were well attended but there was a decided preference for topics of a general nature which could be related to everyday life.

The Lakehead's annual dance held in March this year was an outstanding success with over eighty couples in attendance. The '59 dance committee have a high standard to emulate.
The branch was honored by having a visit from President Dr. K. F. Tupper and the general secretary, Dr. Garnet T. Page. A dinner dance was held in honor of this occasion and a good number of members and their ladies came out to hear Dr. Tupper speak on his impressions of Russia gained on his recent trip to that country.

The Lakehead boasts a very active Wives'Association and they repeated last year's success by sponsoring an excellent supper dance following the cocktail party given by the A.P.E.O. President, Mr. C. T. Carson, for the district engineers and their ladies. Mr. Carson was accompanied by his wife and daughter and by Col. T. M. Medland, executive director.

The ladies are not solely concerned with social activities and for the last several years have donated a bursary to be given to a deserving student as recommended by the Lakehead College of Arts Science and Technology.

LETHBRIDGE: Following is a statistical summary of Lethbridge Branch activities during 1958.

Number of regular meetings	4
Average Attendance	37
Number of special meetings	2
Attendance	40
Number of field tours	1
Average attendance	40
Number of executive meetings	5
Average attendance	6

The branch did not operate a professional development course during 1958.

In January the film "The Eighth Sea" depicting the St. Lawrence Seaway Project was shown to the members at the regular monthly meeting. A paper, suitably illustrated by slides on "Hydraulic Model Testing", was presented to the February meeting by C. D. Smith, Hydraulics Engineer for the P.F.R.A. at Saskatoon.

In March, the Branch was given a talk entitled "A Forward Look at the Telephone Industry" by Mr. H. J. Childs, Switching and Planning Engineer with the Alberta Government Telephones.

The October meeting took the form of a joint dinner meeting with the Association of Professional Engineers, which was followed by a panel discussion on "Professional Affairs". The panel consisted of Dr. Govier, President of the A.P.E.A.; A. E. McDonald , Executive Secretary of the A.P.E.A.; C. A. Stollery, Vice-President of the A.P.E.A.; and J. F. McDougall, Registrar of the A.P.E.A.

The highlight of the year was the noon luncheon meeting in November at which time the branch was honoured by a visit from President and Mrs. K. F. Tupper and the General Secretary of the E.I.C., Garnet T. Page. Following luncheon, a very enlightening field trip was taken to the Canadian Sugar Factories plant at Taber, Alberta.

The annual "Engineers Ball" was held in December, a successful climax to the year's activities. All the meetings were dinner meetings, and the branch was again fortunate in having Mr. and Mrs. G. Brown provide the dinner music, a tradition with the Lethbridge Branch for over thirty years.

The Ladies Auxiliary had a very successful and active year. Regular monthly meetings were held with bridge parties on alternative months, and guest speakers at the other meetings covered many interesting topics. The Highlights of the year were the tea and luncheon tendered Mrs. K. F. Tupper when she accompanied President, Dr. K. F. Tupper on his visit to Lethbridge in November, and the year end banquet held at the Flying Club in May.

LONDON: A Professional Development program was organized by the London branch for the 1957-1958 season. Two separate groups were active and total registration for group A was 13 with an average attendance of 6 while total registration for group B was 41 with an average attendance of 17.

The branch co-operated with the Guidance Dept. of the London School Board at their career exposition and assisted the association of Professional Engineers with a display booth at which high-school students could make enquiries about engineering as a career.

The Engineers' Wives Association organized 4 social events during the year and entertained the President's wife at luncheon on November 28th at which time they presented her with a souvenir coffee spoon of the city. Membership in the Wives' Association for the year was 146.

The branch generally enjoyed a very successful year.

LOWER ST. LAWRENCE: The Branch held two smokers at Rimouski early in the year, and on October 27th, the new executive was elected at a gathering of engineers from Rimouski and the surrounding area.

A ballot was held to determine the type of program to be organized for the coming season, and it was agreed that there would be two mixed social events, one technical meeting, one industrial visit to the North Shore and two smokers.

On October 20th, a special dinner meeting welcomed the Field Secretary, Mr. J. McLaren, and on December 13th the members and their ladies held an enjoyable dinner party.

MONCTON: Nine technical and social meetings were held during the year. In January, J. D. Cunningham, public relations officer, N. B. Telephone Co., gave an address on the future of the telephone.

A combined meeting of the Amherst and Moncton branches was held in February, at which, Fr. Burke-Gaffney spoke on space travel and related subjects. Nominations for 1958-59 branch officers were received at the March meeting. Also, at this meeting, slides were screened showing the pre-stressed girder bridge, under construction, connecting Shippigan with Shippigan Island. The annual meeting of the branch was held on May 26th. During the summer, a Saturday afternoon cruise on Shediac Bay, arranged by Lloyd Parsons, was cancelled at the last moment because of stormy weather. Instead, branch members were entertained at the shore cottage of Mr. and Mrs. Parsons. The fall season opened in October with an address on investments, stocks and bonds by W. A. Shaw, Moncton manager of Anglin, Bell and Co. In November, the branch heard G. G. Fisch speak on professional management today. On November 13th, the executive entertained J. A. McLaren, Eastern Field Secretary, at dinner and afterwards held a round table conference with him.

The branch membership now numbers one hundred, the largest in some years. The branch does not operate a professional development course and has no counselling committee for high school students.

We regret to record the passing of William James Edington, M.E.I.C., whose death occurred on September 25th.

The Engineers' Wives Association of Moncton branch, has a membership of sixty. Mrs. W. M. Steeves is the president and Mrs. V. C. Blackett the secretary-treasurer. Four social affairs and business meetings were held during the year, the first being a bridge at the home of Mrs. W. A. Purdy, on February 7th. The annual meeting was held on May 9th, at the home of Mrs. J. W. Demcoe, and officers for 1958-59 elected. Bridge was played after the business of the meeting had been concluded. On November 13th, a very successful pot-luck supper was held at the Y.M.C.A. The group was addressed by Dan Billing, Co-ordinator of Civil Defence for southern New Brunswick. On December 5th, a Christmas dance and buffet supper was held in the Brunswick Hotel, to which members of Moncton branch were invited.

MONTREAL: The activities of the branch are numerous, and only some of them can be mentioned in this report. This does not lessen the appreciation of the untiring efforts of all those who contributed to the successful program of the past season.

Special committees are now studying problems in evening education, French-English membership and branch communications. The committee on French-English Membership is of special interest, since it is unique to branches having bilingual or multibilingual membership. Its purpose is to determine whether the proportions of French speaking and English speaking members of the branch bear some reasonable relationship to the relative proportions of these two language groups in the total population of Montreal, and if not, whether any steps can be taken to bring the proportions more nearly in line with what it is felt they might be.

1958 activities included the annual meeting, students night, a National Film Board tour, a pre-summer social, a golf tournament, the annual dance, a smoker and talks on the "Ville Marie Project" and "Construction of Bersimis No. 2". The Professional Development Seminar consisted of a series of lectures on Management and Leadership, Organization, Planning, Forecasting, Control, Business Financing, Marketing and Advertising, Labour Relations, Chairmanship and Taxation. It was attended by approximately 45 members. The Junior Council held regular monthly meetings, and prepared interesting functions and meetings for the 1400 Junior E.I.C. members.

A Telephone and Publicity Committee operates in the Montreal branch. Its main functions are to contact and advise members by telephone and to write and edit reports on meetings and other functions.

A Special Studies Committee was formed to inquire into ways and means of improving the Branches programs and activities, and a Social Club Investigation Committee was given the task of determining the feasibility of organizing a social club for engineers and friends who could meet informally for luncheons and other planned activities. Student representatives were very active at the universities, and more than 100 students attended the Students Night.

The technical sections presented varied programs. Thirty-four interesting papers were presented, and a number of field tours were made.

In the course of the year the branch organized two forums to acquaint graduating high-school students with the profession of engineering, its challenges, its rewards and its responsibilities. Work also advanced on the preparation of a manual on student guidance which it is hoped may be made available to branches throughout Canada.

NEWFOUNDLAND: The branch had another successful year with good turnouts at monthly meetings, and a favorable financial situation existed.

During 1958 we held seven general and six executive meetings. The general meetings took the form of dinner meetings, and we were fortunate in securing prominent speakers for each of these occasions. Some of our speakers were Dean D. L. Mordell, M.E.I.C., McGill University, and Mr. J. A. McLaren, M.E.I.C., Field Secretary.

As in previous years, we had a students night at which three engineering students from Memorial University presented papers on the subjects of their choice. Mr. G. Moores was awarded the prize of $50.00 for his paper on Stock Market Trends.

The social highlight of the year was the annual dance in April.

NIAGARA PENINSULA: The 1958 program began on January 30th when a joint EIC - APEO meeting was held at Niagara Falls. On March 15th, many members attended the Regional Technical Conference at Hamilton, and in April members enjoyed a tour of the Atlas Steel Plant in Welland, followed by dinner.

The Niagara Peninsula Branch Annual Meeting, which is also the Annual Ladies Night, was held on May 9th. Following the reception and dinner an interesting talk on glass was heard. The pre-vacation program ended in June with a visit to the Huntley Generating Station at Buffalo, N.Y.

The 5th Annual Professional Engineers Ball was held on September 26th in co-operation with the APEO and was attended by approximately 200 couples. In October the branch listened to an interesting talk on Education and Technical Advances in Russia, and in October they were addressed on the subject "Building a Greater Canada".

The President's visit to the branch took place on November 27th, and on December 4th the final meeting was held at which a paper on the Burlington Skyway was presented.

The majority of EIC events in this region are held as joint affairs with APEO, and this arrangement has been most satisfactory.

NIPISSING AND UPPER OTTAWA: No professional development courses were offered by the branch in the past year. Counselling for high school students was carried out in 1958 and a "Student's Night" was successfully held in March with 29 Students in attendance at a dinner meeting. This event is again planned for next year.

Highlights of the year included the visit of President Tupper and General Secretary Page and a field trip to the Atomic Energy Plant at Chalk River.

Our Branch does not have an Engineers' Wives' Association, as such, but on the occasion of the President's visit, an afternoon tea was held by the wife of our Branch Chairman in honour of Mrs. Tupper.

NORTH EASTERN ONTARIO: This branch was in the process of reorganization during 1958, and no formal program of activities was carried out.

NORTHERN NEW BRUNSWICK: The branch held a total of eight meetings during 1958 including five general, two executive and the annual meeting. Attendance at the general meetings averaged about 40% and at the annual meeting about 60% of the active membership. Branch membership totalled 65 on December 31, 1958 as compared to 62 on the same date in 1957.

The first general meeting of the year was held in Dalhousie on February 21. The guest speaker was Mr. R. C. Eddy, M.E.I.C., of Bathurst, who gave an interesting talk on the Sematic Reaction, or S-R-Grid.

The second general meeting was held in Bathurst on March 28. Following a business meeting, the members saw the film "Our Mr. Sun", supplied by the New Brunswick Telephone Company.

The third general meeting was held in Newcastle on May 10. Guest speaker was Mr. H. D. Scully, manager of Nesbitt, Thomson & Company Ltd., Saint John, N.B. Mr. Scully gave a very interesting talk on the services rendered by an investment dealer and on the different types of securities on the market.

The annual meeting was held at the Country Club in Dalhousie on June 6, with the ladies present. A brief business meeting was held to provide for the installation of new officers. The guest speaker was Mr. E. A. Barks, Regional Meteorologist of the Atlantic Provinces. Mr. Barks gave an interesting outline of the development of weather forecasting in which he covered the growth and scope of the weather services of Canada.

The fourth general meeting was held in Campbellton, on October 1, The guest speaker was Mr. G. B. Lawson, who until recently was a design engineer with Fraser Co. in Edmundston and is presently associated with Fraser Co. sales division in Montreal. Mr. Lawson gave a very interesting and aptly illustrated paper on the new steam plant extension at Fraser Co's Edmundston mill, which produces pulp for the Fraser Co's paper mill in Madawaska, Maine.

The fifth and concluding general meeting of the year was held in Bathurst on November 18. Guest at this meeting was Mr. John A. McLaren of Toronto, the Eastern Field Secretary of the Institute, who was completing his first Maritime tour. Mr. McLaren's talk concerned the many functions of the Institute and he pointed out that one of his main duties was to bring the facilities of the Institute's Headquarters closer to the outlying Branches. Two films, entitled, "Ripple Rock", a description of the April 5 demolition and "The Eighth Sea", a description of the St. Lawrence Seaway Developments were then shown.

NORTH SHORE LOWER ST. LAWRENCE: The branch had a very active and successful year with the main activities being five dinner meetings and two field trips. Mixed dinner meetings are found to be especially successful and talks were heard on the following subjects: "The Canadian British Aluminium Development", "Arctic Construction", "Town Planning", "The Early History of Knob Lake Area", and "Aerial Photography for Engineering Construction". On March 21st a party of engineers made a field trip to Mile 84, Bell Telephone Site for installation of micro-wave scatter system. On July 19th a party of engineers made a field trip to the tanker "Imperial Edmonton" which is participating in an inovation of having an oil tanker remain in port to fuel ore carriers.

The program was very well supported by members and their guests and in general the branch had a very successful year.

NORTHERN NOVA SCOTIA: This season's activities commenced with an executive meeting on June 19 at which time arrangements were made for election of new officers and other matters were discussed.

The first general meeting was held on July 31 and Dr. Mordean Goodman, formerly professor of geology at Dalhousie University, was the special speaker. Dr. Goodman's address on the principle methods of geophysical explorations was well received by the small group present.

The ballots were opened at this meeting and the election of officers was announced.

A dinner meeting was held on Nov. 10 to welcome Mr. J. A. McLaren on his first official visit to this branch.

The group, consisting of fourteen members and Mr. McLaren, was entertained during dinner by bagpipes and Scottish dancing. After dinner two interesting films were shown, "the Demolition of Ripple Rock" and the "Construction of the Railroad from Seven Islands to Knob Lake". Mr. McLaren also addressed the meeting, outlining the functions of the E.I.C. Library and other services of the Institute.

The next meeting will be called early in February and the main thing on the agenda of that meeting will be a discussion of Confederation.

OTTAWA: The Ottawa Branch held 16 functions during 1958—10 luncheons, 3 evening meetings, one field trip, one dance, and the annual spring golf tournament. All but one of these were held jointly with other engineering groups.

Attendance averaged 80, with a maximum of 125. The field trip was attended by 75 people.

In May, the chairman and treasurer joined the President and General Secretary in launching another satellite of the Ottawa Branch, The Chalk River Branch.

Our most exciting task for the year was preparing for the celebration ceremonies and a banquet to mark the Fiftieth Anniversary of the Ottawa Branch. Under the chairmanship of Mr. R. F. Legget, a semi-centennial committee was set up early in the year, and the first fruit of this committee's labours was a banquet held on 17 January, 1959.

In addition to chairing this committee, Mr. Legget prepared, in collaboration with Mr. S. G. Frost, a history of the Ottawa Branch, published in booklet form as a souvenir of the Semi-Centennial.

PETERBOROUGH: Following a very interesting spring program, the Branch held a successful Golf Day on June 28th. The fall program consisted of four meetings at which speakers dealt with general subjects, a very successful field trip to AECL at Chalk River, and a "Pub" Night.

As in past years, the Branch has co-operated in student guidance where requested, but has relied on the various other organizations operating in the area to do the bulk of the planning.

The Engineers Wives Association organized a number of interesting events, and reported a very successful season.

PORT HOPE: During the year 1958 the branch held six meetings with an average attendance of 20, except on Ladies Night when more than 40 were present.

In January the branch received a talk on "Personality Development for Executives and Foremen", and in February the subject was "Do You Keep a Notebook?" A field trip to Toronto to view the hydraulic model of the St. Lawrence Seaway was organized for April and in October a talk on "Investment Outlook for 1959" was received. The year's activities ended in November with the showing of a film "Atomic Energy in Canada".

PRINCE EDWARD ISLAND: Five regular meetings were held during the year 1958, of which three were dinner meetings and one was a film and lecture night. These were held jointly with the Association of Professional Engineers of P.E.I. The fifth meeting was our annual picnic, which was held at Keppoch Beach at the cottage of the Chairman, C. W. Currie.

The annual meeting was held at Charlottetown on November 11.

There were no professional development courses conducted here but three short lectures were given to student engineers.

QUEBEC: Le point culminant des activités de la Section de Québec au cours de l'année 1958 fut sans doute la tenue de l'Assemblée Générale Annuelle de l'Institut dans nos murs. Plus de neuf cents délégués y assistaient. Le Comité Exécutif offre ses remerciements au Président du Comité d'Organisation, M. Ben O. Baker, et à tous les membres de ce comité dont les efforts ont grandement contribué au succès remporté.

Quatre conférences techniques ont été présentées cette année. La réunion conjointe du mois de janvier où l'on présenta des travaux sur quatre aspects différents de l'étude des satellites fut sans contredit la mieux réussie de l'année. Plus de trois cents personnes étaient présentes. L'assistance aux trois autres conférences fut d'environ vingt-cinq.

Le tournoi annuel de golf de la section, tenu le 15 septembre au club de golf Royal Québec, a été encore une fois l'événement social le plus populaire de l'année. Une soixantaine d'ingénieurs de Québec participaient avec leurs épouses aux différentes activités de la journée.

Le Comité exécutif remit au programme une partie d'huitres qui eut lieu au début de décembre. Malgré cette période de l'année moins propice aux activités de ce genre, une quarantaine de membres répondirent à l'appel.

Au début de septembre, le Conseil de la Section, de concert avec l'association des diplômés de Polytechnique, avait le plaisir de recevoir la visite de M. Robert l'Hermite, directeur des laboratoires des Travaux Publics et Bâtiments de France. Notre visiteur exprima son ardent désir de promouvoir des échanges de vues entre ses confrères de France et les ingénieurs canadiens.

C'est avec un vif plaisir que le Comité Exécutif souligne la nomination de M. Guillaume Piette, à la Présidence de la Corporation des Ingénieurs Professionnels de la Province de Québec, et aussi l'élection au Parlement Fédéral de Messieurs Maurice Bourget et Yvon Tassé, tous membres de la Section de Québec.

Grâce à la coopération du Ministère Provincial du Bien-Etre Social et de la Jeunesse, nos membres ont eu encore cette année l'opportunité de suivre des cours de perfectionnement en structures.

SAGUENAY: The Saguenay branch has just completed another interesting and active year. The executive met 11 times to discuss Institute affairs and to consider the activities planned by the various committees. As usual, all activities were run in co-operation with the Saguenay Chapter of the Corporation of Professional Engineers of Quebec. This arrangement has proven to be of mutual benefit. The meetings committee did an excellent job, organizing a total of 8 meetings in the course of the year.

not counting the annual meeting. These meetings covered a variety of subject material including physics, lubrication, mining, finance, instrumentation, metallurgy, sales, hydro-electric power systems and local history. Two of these meetings were organized jointly with the local branch of the C.I.C. In addition, there were three field trips. The Spring program of the professional development activities consisted of two subjects: "Experimental Design" and "Public Speaking". Each group held six meetings and total registration was 19 of whom it is estimated that 75% attended.

The Autumn program consisted of three courses, Investment Policy for the Individual, Statistics, and Great Books. The first two were held both at Arvida and Isle Maligne while the last course was held only in Arvida. Ten meetings are scheduled for the branch year. Registration is 44 and average attendance runs at approximately 80%.

With the co-operation of local branches of the C.P.E.Q. and C.I.C. a series of talks is held each year at local high-schools. The talks usually last about an hour and are followed by an informal question period. In 1958 a meeting was held at each nine schools and a total of 384 students attended. This program has been enthusiastically received by the school administrations.

SAINT JOHN: In addition to the annual meeting, the Saint John branch held four dinner meetings, four professional development meetings, two plant visits, a picnic and a Hallowe'en party.

The average attendance at the dinner meetings was 34 and talks were heard on:

"Broader Education for Engineers"
"A Forward Look at the Telephone Industry"
"An Engineer Looks at Space Travel"
"Professional Management Today"
"The New Thermal Power Plant in East Saint John"

The professional development series included the following subjects:

"Art and Architecture"
"The Saint John Exhibition"
"Saint John — Its Past and Future"
"Historic Fort LaTour".

There was no definite enrollment for this course but members' wives were invited to each meeting and the average attendance was 32.

At the executive meetings, seven of which were held, the average attendance was seven. In addition, the Board welcomed the eastern field secretary, John McLaren, in November to an executive luncheon at which twelve were present.

As usual, the plant visits proved to be very popular and the picnic and Hallowe'en party provided notes of variety which attracted several members to their initial appearance at our functions.

ST. MAURICE VALLEY: 1958 was marked by a 14% increase in E.I.C. membership in the St. Maurice Valley. This was due partially to existing members being transferred to the Valley and partially to a concentrated membership drive by the Membership Committee during the early part of the year. There were 9 general meetings held including the E.S.J.C. dance in May and the E.S.J.C. golf tournament held in August.

The year's activities began with a smoker and film night held in Shawinigan during February. This was followed by a mixed dinner meeting in Three Rivers in March. This was strictly a "Ladies' Night" with the T. Eaton Company supplying a speaker on "Home Decorating and Furnishing". The men again regained their domination however, with three members of the branch making up a panel discussion on cameras and photography, this meeting being held in Shawinigan during April.

At the end of May the annual dinner meeting and election of officers was held in Shawinigan, with Brigadier C. Wallis, a member of a management consultant firm as guest speaker. In the middle of June a joint field trip with the C.I.C. was held, with the group visiting the Beaumont Power Development of the Shawinigan Water and Power company some ten miles north of La Tuque. This concluded the Society's activities for the summer months with the exception of the annual E.S.J.C. golf tournament held in the Ii-8-Eb country club in Three Rivers in August. Some 130 golfers took part in the "Duffers Tournament" with approximately 170 members attending the buffet held in connection with the tournament and at which the noted sports columnist Baz O'Meara was guest speaker.

The regular fall activities resumed in October with a general meeting in Three Rivers at which Mr. L. F. Tsao, noted Chinese journalist, business man and former member of the United Nations Secretariat gave an extremely interesting insight into the present China situation. It was appropriate that the final meeting of the year, was without doubt one of the most interesting, with Dean D. L. Mordell, Dean of Engineering at McGill University speaking on "Satellites".

This year did not include a visit from the President with Dr. Anson having visited the branch in November 1957 and Dr. Tupper scheduled to arrive here in February 1959. There was no professional development course held during the year, although it is hoped, after the extremely successful one in 1957, to plan one for the fall of '59 or the early winter of 1960. No active counselling was carried out in the schools, however, a one year bursary honouring a life member of the branch, Mr. F. X. T. Berlinquet was given to Laval University and was awarded a St. Maurice Valley engineering student, Mr. Bernard Beland. The branch has retained its predominately male character with no Engineers Wives' Associations having been formed.

Six executive meetings were held during the year, with alternate meetings being held in Shawinigan and Three Rivers.

SARNIA: Ten meetings held during the year included a smoker, organized and run by the juniors of the branch, a dinner dance on the occasion of the President's visit, the annual meeting with the election of officers and seven meetings at which speakers were heard on the following subjects: "Investments", A Detergent Alkylate Plant", "Industrial Television", "Rocket Fuels", "Forestry Engineering and the Canadian Pulp and Paper Industry", "Safety and the Engineer" and "Professional Management Today".

During the year the membership of the branch increased from 158 to 165. The branch, in co-operation with the Provincial Association made arrangements for candidates to write professional engineers exams in Sarnia. A member was also provided to serve on the Harbour Advisory Committee which is assisting the city to prepare for the opening of the St. Lawrence Seaway.

The professional development course was most successful and consisted of a group of qualified speakers discussing "The Canadian Economy". Sixty engineers enrolled in the course and the average attendance at lectures was 45.

The branch was active in providing student guidance when requested by local high-schools. The Engineer Wives Association completed their second year of activity. The 75 members assisted in organizing the annual dinner dance as well as carrying out a varied program of their own.

SASKATCHEWAN: The branch had the pleasure of entertaining two Institute presidents in 1958. On both occasions the visiting officers sat in on the regular monthly meeting of the executive committee. Both presidents spoke to the engineering students at the University of Saskatchewan. They joined the membership at a social event in the evening and gave interesting talks on the general activities of the Institute. The branch being located so far from headquarters in Montreal, these visits by the President and the General Secretary have a unifying effect and we look forward to similar visits in the future.

The branch has been active in the organization of a Western Regional Meeting to be held at Banff in October. The Saskatchewan branch is pleased to co-operate with other branches in Zone A to arrange a useful technical program for this meeting. During the year the Saskatchewan branch was represented at two Zone A Council Meetings, one held in Edmonton on March 28th and the other in Calgary on October 18th. The branch was also represented at the 1958 Annual Meeting in Quebec City by Prof. J. B. Mantle. In accordance with the wishes of students at the University of Saskatchewan an officially recognized student branch of E.I.C. was set up during 1958. A regular section was also set up at Regina which had for many years been directly controlled by the executive. Establishment of this section makes the organization more consistent throughout the territory and the Regina section now has its own slate of officers and looks after its own affairs like other sections.

The Engineering Institute Prize for 1958 was presented to Mr. H. D. Barber of the University of Saskatchewan by President Tupper in November.

During the year the branch was visited by Commodore A. C. M. Davy, Western Field Secretary, and by Mr. Henry P. Gatin, Director of Membership Services at Headquarters. These visits improve communications between the branch and Headquarters and are most welcome.

SAULT STE. MARIE: The 1958 season got underway on February 14th, with a talk from the City Engineer on some engineering details, financing, and critical need of a road underpass currently being constructed. The next meeting on March 28th was a non-technical but very interesting talk on history of early Indians in the Sault area by Mr. C. Lawrence. Coloured slides and a display of Indian artifacts accompanied the talk. The May 2 meeting consisted of a field trip through the new Mannessman Seamless Tube Plant. Last minute failure of arrangements caused the cancellation of a mixed-social affair on May 30th. On October 2nd a film on the mid-Canada Early Warning System and a film on the Micro Relay across Canada were shown.

On November 11th we were honoured by the President's visit along with Mrs. Tupper and Dr. G. Page. The annual meeting was held on December 12th.

Attendance of resident members has averaged approximately 45%. Interest was shown by the ladies during the presidential visit in the formation of a ladies group. Progress on this matter will be reported in 1959.

SUDBURY: On January 16th Father Furlin of the Sudbury University spoke on progress in the establishment of a university at Sudbury. Dr. Bruce Wilson of the Inco Medical Service also gave an interesting talk on Civil Defense. On February 13th Mr. D. W. Grey spoke on "Forest Management" and one month later Mr. Lennox Lane discussed the Sudbury Parking Authority after which Mr. Hugh McGinn spoke on "Ignition Rectifiers". The program at the April

10th meeting for members and their wives consisted of a social evening after which a film on the "Dew Line" was presented. The annual meeting was held on May 8th and was followed by a film on "In Pursuit of Wisdom" presented by the University of Toronto. The joint meeting with the APEO was held on October 7th when Mr. John Fox addressed 105 members of both organizations. The October program consisted of a field visit to the Johns Manville plant in North Bay, and another field inspection tour to the mining property of Falconbridge at Fecunis Lake was held on the occasion of the visit of the President and the General Secretary. This latter trip was followed by a social evening. The program was terminated on December 11th when Bruce Hamilton addressed members on "Stainless Steel".

Seven executive meetings were held during the year but no professional development courses were organized.

The Education Committee carried out vocational guidance programs at eight high-schools in Sudbury and district.

Generally speaking the year's activities were very successful and the average attendance at the seven regular meetings was approximately 41% of branch membership.

TORONTO: Fifteen general meetings were held during 1958. They included the annual branch meeting, two plant visits, nine regular meetings and three special meetings, one a students night, the second a ladies night and the third the occasion of the President's visit. The annual meeting was held on Friday, February 17th, at the King Edward Hotel. The dinner was attended by 135 people and following dinner in the business section the guests were addressed by Prof. M. H. Hewer, Associate Professor in the Department of Mining Engineering at the University of Toronto. The subject of his talk was "The Construction of Hydro-Electric and Thermo-Electric Projects in Pakistan".

The final meeting of the spring session was a visit to Avro Aircraft Limited at Malton, where we were privileged to see the detail of the final assembly shops, the flight line of the Avro Arrow, and films of the first flight of the aircraft.

Fall activities began with a plant visit to Oranda Engines on Thursday, September 25th. Turnout to these plant visits was exceptionally good and a sincere vote of thanks is due Avro Company and their subsidiary organizations for the time and trouble expended in the organization of these extremely interesting plant tours. The nine regular meetings of the branch consisted of papers on the following subjects: "Forest Engineering and the Canadian Pulp and Paper Industry" by C. B. Davis, "From Icarus to Earth Satellites" by B. Etkin, "Education and Industrial Progress in Japan" by K. Piekarski, "The Cost of Housing" by R. F. Legget, "The Iron and Steel Industry in Russia", by P. E. Cavanagh, " 'Ripple Rock' Devil Beneath the Sea" by R. S. Dick Harding, "Satellite City" by Roger B. Dennison, "Some Observations on Engineering Contracts" by Paul H. Mills, "Some Observations on the Future of Metals" by Dr. L. M. Pidgeon.

The attendance at regular meetings varied from 50 to 200 with the average attendance about 100.

Several joint meetings were held by the E.I.C. The first was the meeting on Saturday, March 1st which was held in conjunction with the Royal Canadian Institute, the meeting of October 30th was held in conjunction with the joint area committee which is made up of the E.I.C. and the I.C.E. The meeting of Thursday November 20th saw members of the Toronto section of A.I.E.E. invited as special guests. Toronto branch members in turn were invited to join A.I.E.E. members at their supper club meeting held at Hart House the same evening.

Students night was held at Hart House on Friday, February 7th. The program took the form of the $64,000 Question and master of ceremonies was Prof. L. E. Jones. 28 students participated and prizes of more than $100 were distributed.

Ladies Night was an informal buffet dinner and dance at the Boulevard Club on Friday, November 28th. 250 people attended. The President's visit was held in Hart House on January 7th. Guests and members were given the opportunity of meeting and talking with the President and his associates, at the conclusion of the business meeting.

In addition to the meeting program of the Toronto branch, both the joint I.E.E. - E.I.C. Committee and the Joint Area Committee (Civil) conducted similar meetings of more particular interest to the electrical and civil engineering fields. Considerable interest was shown in these programs especially that of the joint Area Committee, where meeting attendance is comparable to the attendance at the general branch meetings.

Professional development courses organized by the branch are operating actively on a three-year basis. The enrollment is 130. The Toronto E.I.C. Wives Auxiliary had a very satisfactory year and now have a mailing list of 230. Several interesting meetings were held during the year and the group was instrumental in entertaining the wives of the visiting English engineers who visited Toronto last spring.

Counselling activities by the E.I.C. Toronto branch is done at the request of Career Counsellors of which there are many in the high-schools of metropolitan Toronto. Speakers are provided where requested and the branch co-operates in the distribution of the booklet entitled "Engineering Careers in Canada".

The branch wishes to express its appreciation for the help given to the various activities of the Toronto branch of E.I.C. by the Eastern Field Office at 160 Eglinton Avenue East.

VANCOUVER: The Vancouver branch held 17 functions of various kinds during the year. Activities began on January 22nd with the joint meeting with the professional association. This meeting took the form of a panel discussion on "Engineering Ethics" and was well organized and executed. The professional development course began on January 29th and on February 4th the annual get-together with the members of the student section of the Vancouver branch was held. The President of the Institute visited the branch on February 10th and this was one of the highlights of the year. The Structural Engineering Section presented a film on "Construction of the Nelson Bridge over Kootenay Lake" on February 18th and the following week in a joint meeting with the association, the branch toured the new plant of LaForge Cement Company of North America. The March 11th meeting was held jointly with the provincial association and Wing Commander A. L. Bocking spoke on "Air Defence in North America". On March 18th the Structural Section again presented a film on "Construction of the Pontchartian Bridge". On March 22nd members and their families visited the Stanley Park aquarium and were given a behind-the-scenes tour. The annual branch meeting was held on April 16th and Dr. Chris Riley spoke on "The History of Mining in British Columbia". The Seattle chapter of the American Society of Civil Engineers entertained members and their wives royally on May 17th and in June the branch viewed a film entitled "The Powerful Horseshoe" dealing with the Niagara Development and enjoyed a field trip to C.P.A. where the new Bristol Britannia was open for inspection.

The fall program consisted of an interesting talk on small boats by John Brandlmayr, an illustrated talk on "Welding Failures" by R. Clough, an illustrated talk on "Avalanche Defence" by Mr. Peter Schaerer and a field trip to one of the sites of the B.C. Telephone Company Micro-wave System. One of the major events of the season was the annual ladies night, formal, at the Hotel Waldorf.

VANCOUVER ISLAND: The branch had an interesting and active season and the general program was well received by the members. Professional development courses were not organized as it is felt that there are sufficient night-school and college courses available to members wishing to participate in such activities. The branch provides counselling services when requested by high-schools but has not organized a formal counselling service. The branch supports an Engineers' Wives Association which has just completed an active and successful season.

WINNIPEG: The affairs of the branch were carried out in a commendable manner by those responsible for operation of activities.

The situation in respect to the attendance at meetings has improved.

During the year we were fortunate in that two Presidents visited the branch. In the spring, Mr. Anson was here and paid a visit to the students section at the University of Manitoba and in the fall Dr. Tupper was with us for two days, during which he met with members of the branch. He had luncheon with the president of the University and afterward addressed a gathering of the students and in the evening had an interesting meeting with the Branch Management Committee.

A professional development course was not organized this year. There was diversity of opinion regarding the kind of course to be given and these did not become sufficiently reconciled to permit the carrying out of this feature of branch function in 1958.

During 1958, which was the fifth full year of operation, five meetings of the civil section were held and the section executive convened on six occasions. Two plant visits were made and one social event held.

At the general meetings an average attendance was forty-two. Plant visits appeared to have more appeal as fifty members attended each of these. The section membership is now two hundred and twenty-five.

The Electric Section held six general meetings, with an average attendance of 42. Three plant visits were made and the overall average attendance was 59.

The membership increased during 1958 to 183. However, as a result of the survey taken near the end of 1958, a cutback reduced the number on the mailing list to approximately 100.

The attendance is increasing somewhat, but there remains much room for improvement.

The student section holds monthly meetings during the academic year and the subjects dealt with are varied in substance and in methods of presentation. Films are used extensively, but the section and the branch endeavour to obtain speakers for student meetings.

The approximate membership of the Student Section is 350, with an average attendance of 200 at regular meetings.

Eight regular meetings of the Brandon section were held during the year. The regular meeting date has been the third Monday of each month and has taken the form of a supper meeting, with a guest speaker.

Average attendance for the year has been approximately 17 — the lowest attendance being 12 and the highest being 37. The largest attendance was on the occasion of a tour through the newly-opened Brandon Thermal Electric Station. This was the only field trip of the year.

Five executive meetings were called during the year. The chief function of the executive meetings was to line up programs of adequate interest for the regular general meetings.

During the year this section again experienced a considerable turn-over in membership. The number of names on the mailing list has remained fairly constant with about fifty notices of meetings sent out each month. However, the prime task of the section appears to be the problem of creating sufficient interest in the new residents to fill the gaps left by those who have been moved away.

The Winnipeg Branch held six regular meetings, with an average attendance of 70 and the Management Committee met six times and had interesting meetings with Dr. Anson and Dr. Tupper and with the General Secretary, Garnet T. Page.

YUKON: Membership in the branch is small, and most corporate members are also members of the professional engineers association, hence the majority of our meetings are joint meetings. The program consists of monthly meetings, and each summer a field trip is organized to some project of special interest. Meetings are generally in the form of a dinner followed by a talk or films of interest to all. The subjects covered in 1958 included construction, soils engineering, and general topics.

ONTARIO DIVISION:

A Statutory Meeting of the Ontario Division was held in Hamilton on March 15, 1958, at the time of the Regional Conference. Several important matters were discussed and the new officers for 1958 were installed. They were:

Chairman	— M. A. Montgomery
Vice-Chairman	— H. R. Sills
Treasurer	— G. R. Turner
Secretary	— J. G. Hall

Members of Board of Managers:
Dean Conn, P. Buss and E. R. Davies

A Statutory Meeting of the Ontario Division was held in the Royal York Hotel in Toronto, on January 24, 1959. It was attended by 16 members.

The Treasurer's Report showed a balance at the end of 1958 of $101.14.

It was noted that three Regional Conferences are scheduled for this year in Ontario, namely in Hamilton, March 14, Sudbury, April 25, and Ottawa, October 15, 16, 1959.

It was decided to hold a meeting of the Ontario Division in Hamilton at the time of the Hamilton Regional Conference, on March 14, 1959.

The officers for 1959 are:

Chairman	— H. R. Sills
Vice-Chairman	— W. J. Ripley
Treasurer	— G. R. Turner
Secretary	— John G. Hall
Board of Managers:	Dean Conn, P. Buss, E. R. Davies

Membership and Financial Statem

BRANCHES	Amherst	Baie Comeau	Belleville	Border Cities	Brockville	Calgary	Cape Breton	Central British Columbia	Chalk River	Corner Brook	Cornwall	Eastern Townships	Edmonton	Fredericton
MEMBERSHIP														
Resident														
Hon. Members	..	..	..	..	..	..	3	..	..	..	..	1	..	
Members	28	21	33	71	30	341	50	41	9	15	34	27	304	
Juniors	7	27	18	61	27	205	7	29	37	12	25	37	256	
Students	11	6	7	10	12	39	16	18	14	2	13	75	110	
Affiliates	..	2	1	3	1	1	1	1	..	..	..	..	1	
Total	46	56	59	145	70	586	77	89	60	29	72	140	671	[illegible]
Non-Resident														
Hon. Members	..	..	..	..	..	6	..	..	..	..	..	..	..	
Members	..	..	5	21	4	28	6	..	..	2	4	22	23	
Juniors	1	..	7	13	1	22	3	..	..	3	3	32	42	
Students	..	..	4	8	..	15	2	..	..	..	1	43	22	
Affiliates	..	..	..	..	..	..	..	..	..	..	..	..	..	
Total	1	..	16	42	5	71	11	..	..	5	8	97	87	
Grand Total Dec. 31st, 1958	47	56	75	187	75	657	88	89	60	34	80	237	758	[illegible]
Grand Total Dec. 31st, 1957	45	..	79	185	74	588	73	76	..	49	89	210	733	[illegible]
Branch Affiliates Dec. 31st, 1958	..	21	..	3	8	42	42	14	..	..	..	25	11	
FINANCIAL STATEMENT														
Income														
Rebates from E.I.C. Hq.	65.10	280.00	239.10	521.90	359.05	367.60	50.00	188.40	218.80	140.70	320.30	336.88	308.80	421
Payments by Prof. Assns.	55.90	..	..	1,210.04	..	1,268.04	137.70	..	50.00	..	..	..	1,388.03	136
Branch Affiliates Dues	..	189.00	..	..	105.00	456.00	370.00	124.95	..	..	..	199.70	181.00	
Interest	..	..	..	23.25	..	83.86	..	..	..	..	..	5.57	49.34	3
Miscellaneous	11.64	1,001.35	19.80	47.30	..	..	778.30	5.00	..	88.00	423.00	230.00	..	1,342.
Total Income	132.64	1,470.35	258.90	1,802.49	464.05	2,175.50	1,336.00	318.35	268.80	228.70	743.30	772.15	1,927.17	1,903
Disbursements														
Printing, Notices, Postage (1)	19.74	52.94	41.96	177.00	17.24	1,091.71	42.00	26.93	16.15	9.15	98.29	89.19	835.54	109.
General Meeting Expense (2)	4.10	158.88	140.00	469.15	..	543.00	..	..	17.65	25.00	..	218.96	163.95	1,282.
Special Meeting Expense (3)	77.46	641.38	..	966.55	145.17	545.48	1,082.69	100.12	70.00	45.00	490.65	..	326.82	105.
Honorarium for Secretary	..	..	..	..	..	..	..	..	5.00	..	..	..	100.00	50.
Stenographic Services	..	..	..	25.00	..	401.00	..	..	..	5.00	..	..	10.00	
Travelling Expenses (4)	..	..	..	..	..	6.34	..	..	..	..	..	..	55.00	50.
Subs. to Other Organizations	..	..	..	..	..	500.00	..	..	..	..	..	..	..	
Subs. to the Journal	..	..	..	..	32.00	..	152.48	36.00	..	..	..	53.60	16.00	
Special Expenses	16.10	..	..	35.25	180.05	510.62	..	41.86	..	..	..	60.00	78.66	109.
Miscellaneous	10.00	..	50.00	41.91	20.00	99.55	46.29	534.48	..	3.50	17.40	.75	29.90	14.
Total Disbursements	127.40	853.20	231.96	1,714.86	394.46	3,697.70	1,323.46	739.39	108.80	87.65	606.34	422.50	1,615.87	1,720.
Surplus or *Deficit*	5.24	617.15	26.94	87.63	69.59	1,522.20	12.54	421.04	160.00	141.05	136.96	349.65	311.30	182.
Balance as at Dec. 31st, 1957	105.99	234.84	326.13	1,234.60	234.83	2,382.78	398.51	††550.70	† ..	25.03	290.35	172.97	1,294.37	489.
Balance as at Dec. 31st, 1958	111.23	851.99	353.07	1,322.23	304.42	860.58	411.05	††129.66	160.00	116.02	427.31	522.62	1,605.67	672.

(1) Includes general printing, meeting notices, postage, telegraph, telephone and stationery.
(2) Includes rental of rooms, lanterns, operators, slides and other expenses.
(3) Includes dinners, entertainments, social functions, and so on.
(4) Includes speakers, councillors or branch
* Adjusted to correct revision of 1957 figures

e Branches as at December 31, 1958

Huronia	Kingston	Kitchener	Kootenay	Lakehead	Lethbridge	London	Lower St. Lawrence	Moncton	Montreal	Newfoundland	Niagara Peninsula	Nipissing and Upper Ottawa	Northeastern Ontario	Northern New Brunswick	Northern Nova Scotia	North Shore Lower St. Lawrence	Ottawa	Peterborough
1	4	..	..	..	1	..	..	..	10	..	..	..	..	..	..	..	2	1
19	78	47	30	35	33	87	71	54	1,834	37	96	25	12	15	30	9	408	77
25	84	38	11	35	12	93	15	19	1,224	43	104	23	23	5	16	20	249	70
7	212	25	2	10	2	37	11	22	1,208	41	35	9	6	3	15	4	277	18
..	..	5	..	4	..	1	..	1	17	2	2	..	..	..	..	..	2	4
52	378	115	43	84	48	218	33	96	4,293	123	237	57	41	23	61	33	938	170
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	9	19	18	26	..	..	74	7	1	2	..	11	..	..	19	5
..	..	..	6	26	7	17	..	..	79	19	..	9	..	17	..	..	21	5
..	..	..	3	13	6	24	..	..	65	12	..	5	..	14	..	..	35	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
..	..	..	18	58	31	67	..	..	218	38	1	16	..	42	..	..	75	12
52	378	115	61	142	79	285	33	96	4,511	161	238	73	41	65	61	33	1,013	182
55	316	94	69	151	83	263	ø	81	4,335	154	256	58	41	62	56	26	1,114	178
14	6	..	17	3	40	..	..	4	3	2	..	5	..	..	..	..	4	6
7.60	631.89	351.90	252.60	429.75	40.00	897.25	170.00	148.80	8,906.08	336.35	984.40	196.80	108.60	119.70	53.10	74.85	1,661.60	592.65
..	..	..	..	..	174.00	..	..	76.00	..	..	..	..	..	36.00	112.20	..	..	100.00
..	56.00	..	90.00	36.00	81.00	..	..	35.00	27.00	20.00	..	53.50	..	..	..	..	42.00	4.00
..	..	5.21	..	..	..	..	..	32.39	245.00	..	9.00	..	..	..	..	..	53.59	..
..	623.80	..	468.35	1,050.70	64.50	1,207.00	485.00	689.55	2,541.99	427.81	300.58	790.70	..	216.05	..	470.00	705.41	1,051.27
7.60	1,311.69	357.11	810.95	1,516.45	359.50	2,104.25	655.00	981.74	11,720.07	784.16	1,293.98	1,041.00	108.60	371.75	165.30	544.85	2,462.60	1,747.92
7.18	125.08	118.46	4.50	155.99	70.95	427.35	20.53	47.74	4,157.34	41.24	273.73	47.39	..	42.47	16.85	38.12	899.69	31.36
5.00	23.00	107.98	63.00	141.00	3.00	34.55	47.87	25.00	91.32	100.01	451.29	..	..	69.75	73.15	..	37.13	185.77
4.75	821.74	41.30	583.83	1,040.16	113.53	981.95	533.24	718.90	6,073.16	383.92	232.34	933.31	..	219.11	..	572.75	465.31	1,206.55
..	..	..	..	11.00	35.00	..	..	50.00	900.00	..	75.00	..	..	..	..	..	100.00	..
7.28	..	25.00	..	..	..	10.00	..	..	..	..	15.00	20.00	..	..	..	..	75.79	..
..	50.00	28.90	60.00	..	..	..	50.00	20.00	155.22	..	..	..	100.00	..	..	..	..	..
2.00	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	250.00	100.00
..	..	..	76.30	12.00	..	..	..	16.15	12.00	4.00	..	16.00	..	..	..	..	12.00	..
..	75.00	2.25	9.98	10.80	..	123.48	72.13	..	236.73	75.00	41.55	..	..	40.65	..	..	590.05	43.90
..	48.35	..	50.00	..	46.58	1.70	..	86.04	241.38	13.30	10.19	..	.30	..	14.50	..	7.65	4.25
.21	1,143.17	323.89	847.61	1,370.95	269.06	1,579.03	723.77	963.83	11,867.15	617.47	1,099.10	1,016.70	100.30	371.98	104.50	610.87	2,437.62	1,571.83
.61	168.52	33.22	36.66	145.50	90.44	525.22	68.77	17.91	147.08	166.69	194.88	24.30	8.30	.23	60.80	66.02	24.98	176.09
.27	764.01	389.86	534.30	335.68	403.38	385.24	336.28	840.09	*9,490.26	24.19	1,000.84	249.06	234.51	276.98	383.06	99.85	849.28	58.99
.66	932.53	423.08	497.64	481.18	493.82	910.46	267.51	858.00	9,343.18	142.50	1,195.72	273.36	242.81	276.75	444.40	33.83	874.26	235.08

ed to correct revision of 1957 figures.
ranch inaugurated in 1958.
cal Section eliminated from 1957 balance.

†† Balances shown as at Oct. 1957 - Oct. 1958.
ø Figures not available.

MEMBERSHIP AND FINANCIAL STATEMENTS OF THE BRANCHES

Continued

BRANCHES	Port Hope	Prince Edward Island	Quebec	Saguenay	Saint John	St. Maurice Valley	Sarnia	Saskatchewan	Sault Ste. Marie	Sudbury	Toronto	Vancouver	Vancouver Island	Winnipeg	Yukon
MEMBERSHIP															
Resident															
Hon. Members	..	..	2	..	..	..	..	1	..	..	3	..	..	2	..
Members	15	17	124	82	68	87	79	541	22	41	953	350	105	270	12
Juniors	11	10	144	81	22	111	64	63	17	24	712	160	32	232	5
Students	6	12	140	30	27	50	21	211	6	11	334	204	19	294	..
Affiliates	..	..	..	1	1	..	1	..	..	..	5	1	1	1	..
Total	32	39	410	194	118	248	165	816	45	76	2,007	715	157	799	17
Non-Resident															
Hon. Members	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..
Members	..	..	6	1	5	..	..	15	1	3	19	28	18	5	..
Juniors	..	1	14	1	5	..	..	28	8	..	21	52	26	14	..
Students	..	1	20	1	7	..	..	27	5	..	8	13	8	54	..
Affiliates	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	..	2	40	3	17	..	..	70	14	3	48	93	52	74	..
Grand Total Dec. 31st, 1958	32	41	450	197	135	248	165	886	59	79	2,055	808	209	873	17
Grand Total Dec. 31st, 1957	30	36	474	207	116	218	158	777	48	76	2,043	816	197	680	17
Branch Affiliates Dec. 31st, 1958	1	..	..	2	9	..	..	..	11	7	1	1	1	32	19

BRANCHES	Port Hope	Prince Edward Island	Quebec	Saguenay	Saint John	St. Maurice Valley	Sarnia	Saskatchewan	Sault Ste. Marie	Sudbury	Toronto	Vancouver	Vancouver Island	Winnipeg	Yukon
FINANCIAL STATEMENT															
Income															
Rebates from E.I.C. Hq.	95.90	75.00	948.76	689.25	264.10	721.77	601.95	160.00	105.00	270.95	2,830.00	1,579.60	442.00	261.13	100.00
Payments by Prof. Assns.	..	..	..	93.56	96.00	..	..	1,574.98	..	10.00	40.00	..	..	1,050.40	..
Branch Affiliates Dues	6.00	..	..	..	96.00	..	..	..	28.00	56.00	10.00	..	3.00	224.00	40.00
Interest	74.70	..	..	6.22	..	3.95	17.61	..	..	..	103.32	26.73	..	37.50	..
Miscellaneous	100.00	15.00	120.20	1,125.44	2.71	219.35	1,784.79	..	144.10	106.50	1,301.00	852.38	..	213.80	..
Total Income	276.60	90.00	1,068.96	1,914.47	458.81	945.07	2,404.35	1,734.98	277.10	443.45	4,284.32	2,458.71	445.00	1,786.83	140.00
Disbursements															
Printing, Notices, Postage (1)	7.25	..	162.25	150.50	117.65	263.27	88.65	153.26	53.00	153.80	1,730.37	600.47	114.20	586.10	..
General Meeting Expense (2)	50.00	..	5.00	539.07	..	171.13	190.05	..	44.45	61.35	132.83	74.25	30.00	236.18	80.19
Special Meeting Expense (3)	218.75	42.52	157.71	1,062.04	129.51	287.17	1,271.19	559.13	181.45	279.00	1,975.65	1,056.63	219.86	251.05	105.50
Honorarium for Secretary	..	..	150.00	60.00	..	..	..	180.00	50.00	..	258.00	100.00	50.00	250.00	..
Stenographic Services	..	..	50.00	..	30.00	10.00	..	50.00	..	..	..	25.00	..	214.00	..
Travelling Expenses (4)	..	..	..	40.00	84.00	..	82.04	609.38	..	..	..	..	19.00	19.80	..
Subs. to Other Organizations	..	..	..	..	..	..	..	..	..	..	..	50.00	..	5.00	..
Subs. to the Journal	..	..	..	..	8.00	..	..	..	4.00	16.30	..	..	..	112.00	..
Special Expenses	5.00	..	259.49	..	..	102.74	449.90	..	1.00	..	160.00	14.50	100.00	98.00	..
Miscellaneous	..	3.65	41.73	54.05	16.48	27.30	143.09	23.21	11.00	16.65	751.75	3.10	..	219.98	.50
Total Disbursements	281.00	46.17	826.18	1,905.66	385.64	861.61	2,224.92	1,574.98	344.90	527.10	5,008.60	1,923.95	533.06	1,992.11	186.19
Surplus or *Deficit*	4.40	43.83	242.78	8.81	73.17	83.46	179.43	160.00	67.80	83.65	724.28	534.76	88.06	205.28	46.19
Balance as at Dec. 31st, 1957	223.41	28.62	185.58	548.17	633.15	642.55	659.34	2,101.89	*288.95	650.60	4,554.34	* 988.10	359.86	*2,749.29	275.61
Balance as at Dec. 31st, 1958	219.01	72.45	428.36	556.98	706.32	726.01	838.77	2,261.89	221.15	566.95	3,830.06	1,522.86	271.80	2,544.01	229.42

(1) Includes general printing, meeting notices, postage, telegraph, telephone and stationery.
(2) Includes rental of rooms, lanterns, operators, slides and other expenses.
(3) Includes dinners, entertainments, social functions, and so on.
(4) Includes speakers, councillors or branch officers.
* Adjusted to correct revision of 1957 figures.

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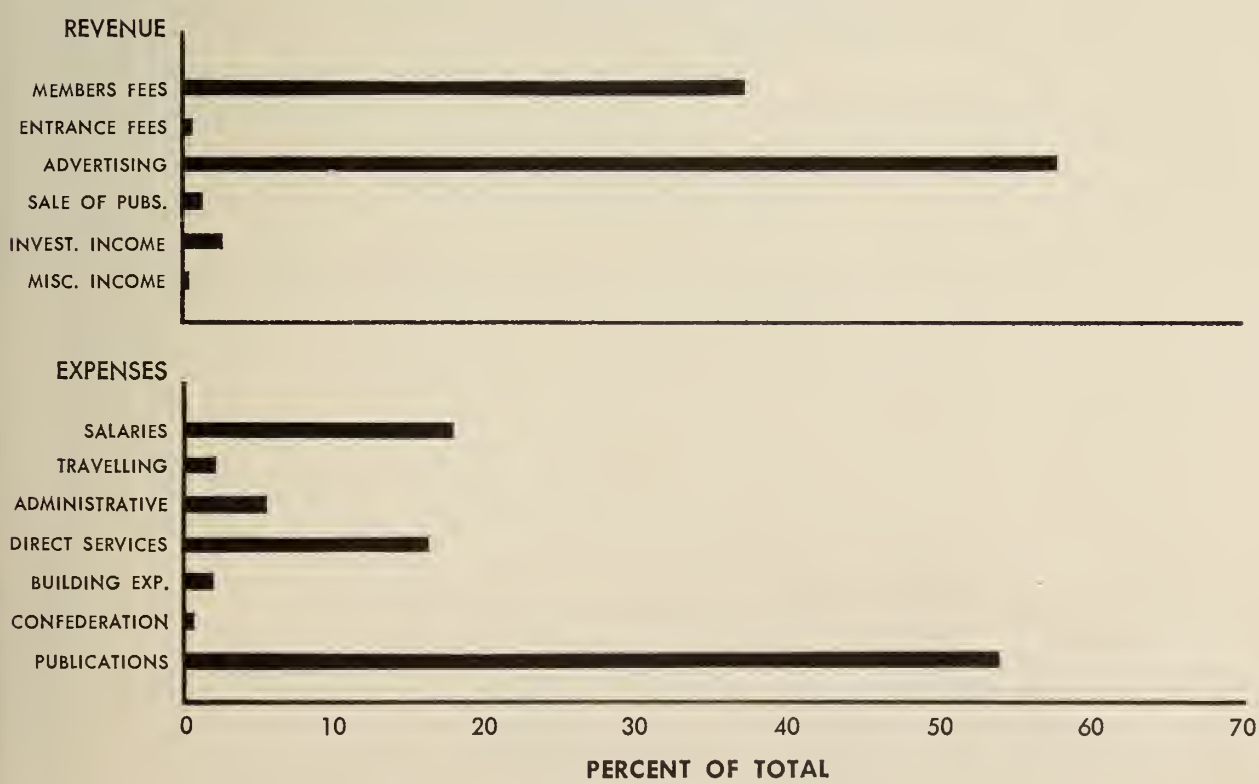

THE ENGINEERING INSTITUTE OF CANADA

FOUNDED 1887

THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: K. F. Tupper, M.E.I.C. Treasurer: T. W. Eadie, M.E.I.C. General Secretary: Garnet T. Page, M.E.I.C

MAY 1959

vol. 42 no. 5

Review of 1958

Current Events

Professional Affairs

Employment and Business

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

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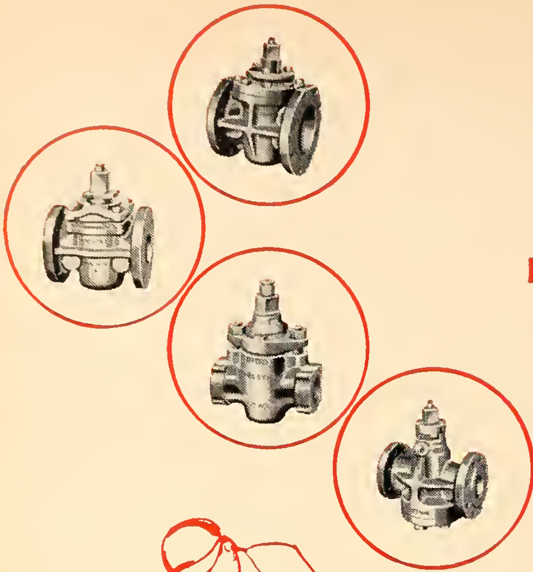

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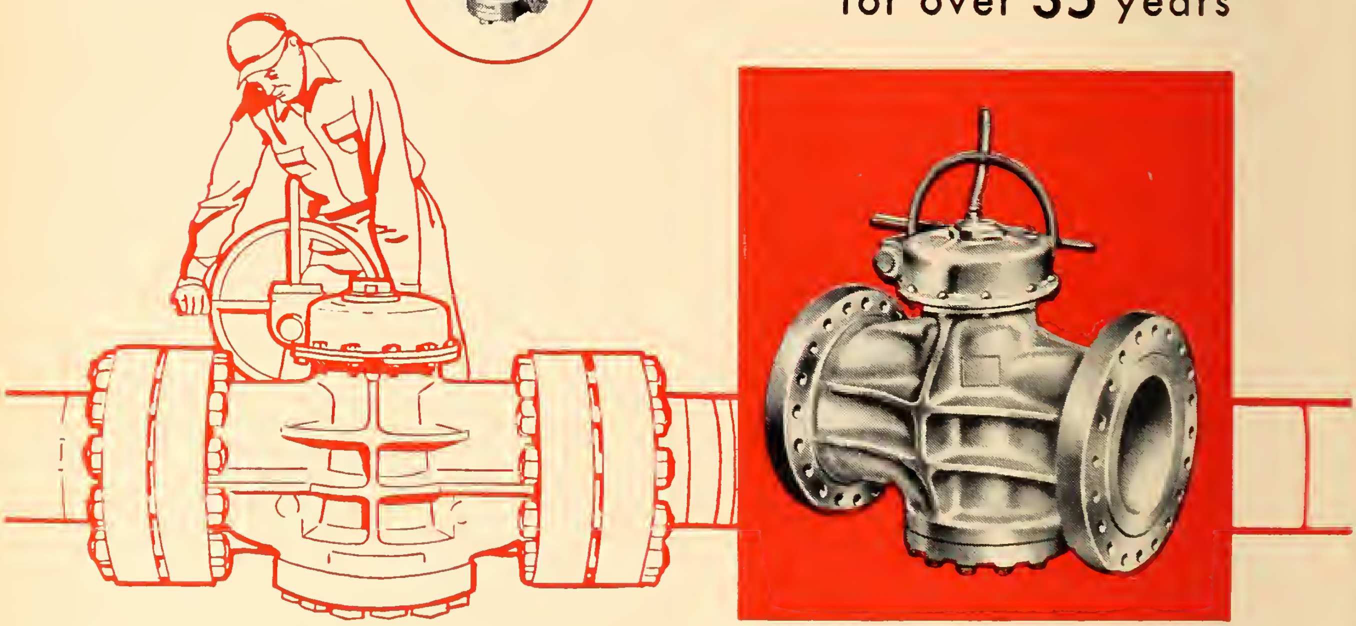

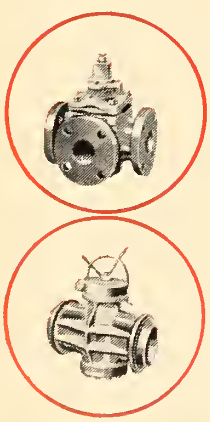

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CANADA IN 1958

THE CANADIAN ECONOMY, which did not suffer from the 1957-58 recession to the same extent as that of the United States, experienced a modest recovery in the last three-quarters of 1958. Government spending cushioned the effects of the recession but inflationary pressures did not subside.

Though employment on farms and in construction was steady and in the service industries it was stronger, it was some 6 per cent lower in manufacturing and 5 per cent lower in mining. The nation at year-end faced a repetition of the serious winter unemployment situation experienced the previous year, despite a cut in immigration to half the numbers entering in 1957.

Though exports showed little change from the previous year, a sharp reduction in imports brought a substantial cut in Canada's trade deficit. Even with a lower crop yield due to prairie drought, the year-end saw a 12 per cent drop in wheat in storage for export and carry-over. Petroleum production was down 10 per cent of capacity. Electrical manufacturing showed a drop of 7½ per cent due to weakness in sales of 'consumer durables', and motor vehicle sales were down 14 per cent, compared with 1957. The physical volume of construction remained unchanged with buoyant house building compensating for lower industrial construction. But electric power production showed a rise of 7 per cent, retail trade was vigorously maintained, inventory liquidation was believed to have run its course, and 1958 saw continuation of the drop in the consumer debt burden.

Outlook for 1959

Looking ahead to 1959, economists predicted a continuation of the modest recovery experienced in 1958, with private investment slightly lower, federal expenditures maintained and provincial expenditures somewhat higher. They foresaw a gross national product of $34 billion, up 5 per cent in value terms over 1958, though showing little improvement over 1958 apart from continued rises in prices and population. There was increasing concern about the stability of export markets due to the effects of Russian competition and the European common market, as well as to possible further U.S. quota restrictions on imports. The still-unsettled freight rate problem, temporarily solved by the 17 per cent increase granted last year, they pointed out, would remain a lively issue.

Further Expansion—no boom

Trade minister, Gordon Churchill, in a year-end message told Canadians the nation's gross national product at slightly over $32 billion, was up 2 per cent from 1957. The rise had been entirely in prices, however, with volume of production unchanged. Employment held up well, and while the number of jobless also increased, the percentage rise was 'narrowing' sharply from that of a year ago. Personal savings increased from 7 per cent in 1957 to about 9 per cent in 1958, with much of this in liquid form.

Summing up, he found most industries that had suffered in the economic decline had improved by year-end. The rise was moderate but there was "strong indication of a further expansion in market demand." Despite Canada's sensitivity to world market influences, the extent of contraction in the Canadian economy was of much smaller dimensions than that in the United States.

Employment covered in Review

Employment in the mining, petroleum, electric power, transportation construction and heavy manufacturing industries but excluding civil service and armed services, covered in the following review, represents more than 40 per cent of Canada's civilian non-farm labour force, or the effort of some 45 per cent of all paid workers. Those not included are employed in such industries as clothing, textiles, food, beverage, retail trade, printing and publishing, tobacco, rubber and leather footwear, and all service industries.

Sources of information used for each industry are confined to records of production supplied by the Dominion Bureau of Statistics, from financial reports, press statements and from government information releases. In addition, comments and forecasts of industry leaders are quoted, though no general forecasts are made by the Engineering Institute of Canada regarding the outlook for 1959.

THE CHEMICAL INDUSTRY

British American Oil's $25,000,000 gas processing and sulphur plant, officially opened in October, 1958, is one of the largest suppliers of natural gas to the Trans-Canada Pipe Line. The plant is 13 miles southeast of Pincher Creek, and approximately 35 miles from the Alberta Rockies. The 350-foot incinerator stack, right, is visible for many miles.

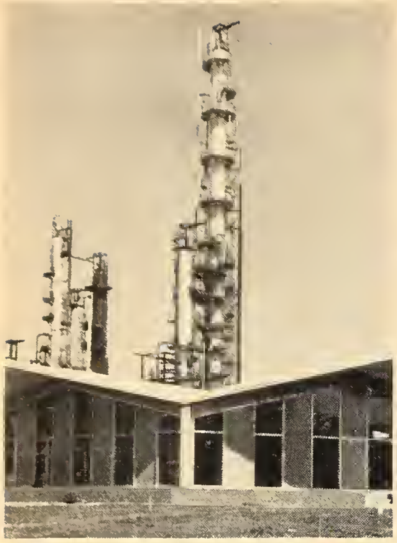
Table I.—Manufacturing Statistics—1957
Chemicals and Allied Products Group

Type of Production	Establishments	Employees	Selling Value of Factory Shipments
			Millions of Dollars
Coal Tar Distillation	11	528	$13.7
Heavy Chemicals	53	10,167	215.8
Compressed Gases	55	1,706	24.3
Fertilizers	45	3,042	83.8
Medicinals and Pharmaceutical	210	8,185	140.1
Paints and Varnishes	129	6,329	131.1
Soaps and Washing Compounds	138	3,650	118.9
Toilet Preparations	91	2,242	49.8
Inks	32	966	16.9
Vegetable Oils	11	656	61.0
Adhesives	29	627	13.7
Polishes and Dressings	47	836	22.3
Plastics (Primary Only)	29	3,452	91.8
Miscellaneous	261	12,215	220.2
Total	1,140	54,601	$1,203.4 Million

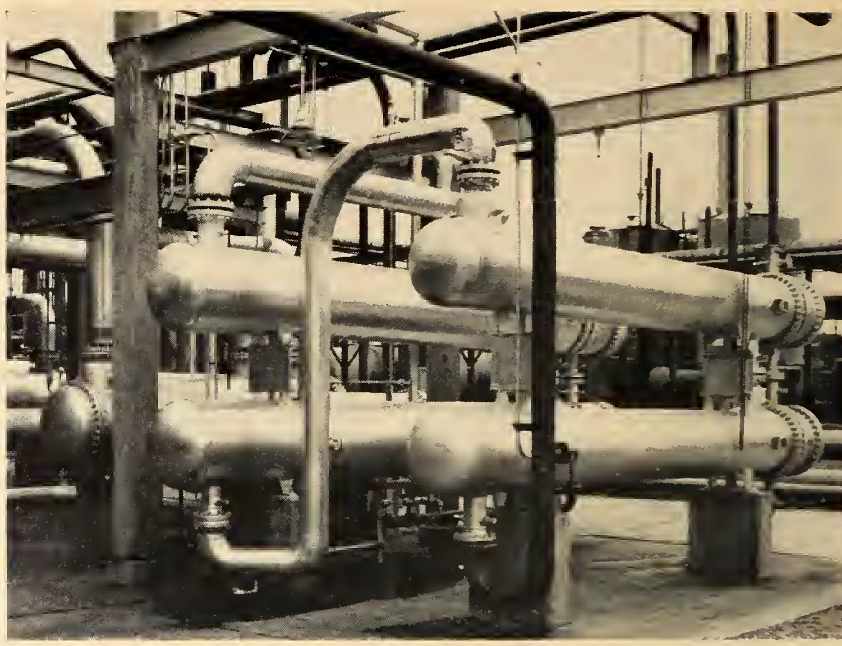
PRODUCTION by the Canadian chemical industry in 1958 attained a new record value estimated at some $1,290 million or 7 per cent higher than in the previous year. The increase in physical volume was close to the average postwar growth rate. The demand for heavy chemicals was strong due to greater uranium ore processing, and capacity for sulphuric and nitric acids and sodium chlorate production had been expanded to serve this growing market. Sales of medicinal and pharmaceutical preparations and detergents increased, as did the consumption of paints. Output from new plants recently placed in operation replaced imports such as titanium oxides and petroleum cracking catalysts.

Measure of the Industry

The Canadian chemical industry is one of the largest in Canada in terms of value of production, and one of the nation's fastest growing industrial groups. It annually ships goods from Canadian factories valued at more than $1,250 million of which about $200 million is exported. In



This skyscraping absorber deethanizer, over 200 ft. high, is the tallest unit processing tower ever built in Canada. It is a vital part of Imperial Oil's $28,500,000 petrochemical plant at Sarnia.



Heat exchangers on stream near Toronto: typical process equipment for the oil refining and chemical industries.

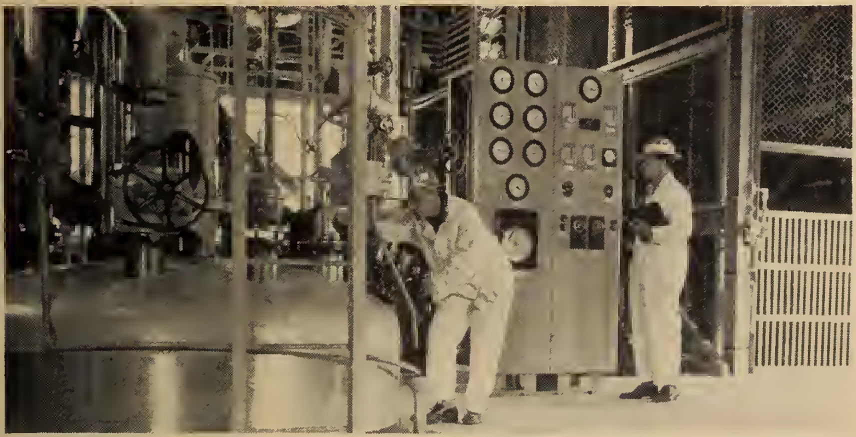
CANADA'S CHEMICAL PLANTS TODAY

Shell Oil Company of Canada's new distillate hydro desulphurizer located at Shellburn Refinery, Vancouver. The 2 million dollar unit was completed at year end.

British American Oil's Clarkson refinery near Toronto.

Shell Oil Company of Canada's detergent alkylate plant at Montreal East which came on stream last spring.

A view of Shell of Canada's Shellburn Refinery unit for the production of a wide range of solvents which was completed last spring.



Left: An interior view of Canada's first epoxy resins plant; the one million dollar Shell Oil Company of Canada unit at Montreal East, P.Q.

Glass lined beer tanks for Molson's Brewery.

addition, imported supplies valued at nearly $300 million supplement Canadian production in the domestic market.

There is a dense concentration of about 1,200 chemical products plants in Ontario and Quebec, though western provinces now have 15 per cent of the total number of plants.

In terms of value of product, chemical production exceeds the clothing industry and approximately equals the value of output by the entire electrical products group. The value of chemical products added per average employe on an annual basis is presently over $11,000—the second highest, next to petroleum refining, among all Canadian manufacturing industries. Production of chemicals represents more than 5 per cent of the gross national product, compared with 3½ per cent in the prewar years and more than double chemicals' share in the 'twenties'.

Capital Investment

Capital expansion during 1958, while large compared with a few years ago, was lower than in either of the previous two years. New investment declined by an estimated 10 to 15 per cent below the $149 million invested in 1957, and included large sums required to complete various projects announced or initiated the previous year.

Only a few of the new plants in operation in 1958, such as those producing epoxy resins, organic phosphates, and inorganic fluorine derivatives constituted initial entry into domestic commercial manufacture. A plant to produce hydrogen peroxide was started up and progress was made on facilities for making high-density polythene and polyacrylonitrile for the first time in Canada.

The use of chemical processes to upgrade waste or by-products was also expanded: lignin chemicals in Quebec; urea from coke oven gases, waste nitrogen and blast furnace gas in Ontario; sulphur from sour natural gas in Alberta. The output of sulphur from Alberta and B.C. sources tripled between 1956 and 1957, and increased still further in 1958. Elsewhere most new capacity added or nearing completion was for chemicals already being produced, such as sulphuric acid chlorine, caustic-soda, sodium chloride and ammonia.

Outlook—Improved Production—Pause in Expansion

Announcement of relatively few large projects recently suggests a further decline for 1959. Though some sectors of the industry see their capacity presently overbuilt, industry leaders see no evidence the decline will be either sharp or prolonged. Though the supply of technical personnel is adequate at present, the long-term outlook is causing concern and further support by the industry in donating funds for education will need to be more widespread.

The effect of the 1957 58 business contraction was moderate and of short duration. There is strong indication the gains in production rates during 1958 will continue. Having added substantially to its productive capacity, the chemical industry should be in a good position to respond to improved economic conditions during 1959.

RUBBER PRODUCTS

CANADA'S SUPPLY of synthetic rubber is produced at Sarnia, Ontario, by Polymer Corporation of Canada Ltd., while the nation's supply of natural rubber is all imported. Polymer, with employment of 1,600 persons, produced 132,000 long tons of synthetic in 1958, or practically the same tonnage as in 1957. Synthetic production is more than 80 per cent in the form of Buna-S, followed by Butyl, neoprene, Buna-N and other types, in that order.

Total consumption of rubber in 1958 by types, based on preliminary reports, in millions of pounds, was: natural, 84; synthetic, 102.4; and reclaimed, 33.36. Consumption of natural was 12 per cent lower than in 1957 while synthetic and reclaimed were down some 8 per cent each. The trend towards the use of more synthetic and less natural rubber continued, with percentages used as follows: natural 37.3 per cent; and synthetic 47.5 per cent.

In 1957, latest year for which a full report is available, factory shipments by the rubber products industry were valued at $326 million, or 8½ per cent below those of the previous record year. Employment stood at 22, 178 persons. Materials used were valued at $144.24 millions. Production was almost entirely in Ontario and Quebec, with factory shipments valued at $265.8 and $59.7 million respectively.

COMMUNICATIONS

AND

TRANSPORT

TELEPHONE

DURING 1958 the Bell Telephone Company, which owns more than two-thirds of all Canadian telephones in operation and accounts for 66 per cent of the employment and 70 per cent of the gross revenue received by Canada's fifteen main telephone systems, continued to develop and improve its services.

There was however a slight levelling off in growth from the number of telephones installed at 185,000, compared with 190,000 installed in 1957. There was, on the other hand, a 4 per cent increase in volume of long distance calling over the previous year, to some 186 million conversations, while total conversations, local and long distance, at some 8.6 billion was higher by 8 per cent than in 1957.

At year-end the Bell System had a total of more than 3,140,000 telephones in service. The list of people waiting for service was reduced during the year from 18,000 to 10,000 and unfilled orders for individual in place of two-party lines from 34,000 to 11,000. Construction to improve the service involved capital expenditures exceeding $180 million.

A Bell Telephone plant craftsman inspects a perforator, one of the many intricate machines required to provide direct distance dialing service at Toronto and Guelph during 1958.

The Industry in 1957

In 1957, the most recent year for which complete statistics are available, Canada's fifteen largest telephone systems represented 96 per cent of total telephone investment. They operated 93 per cent of Canadian phones and earned 96 per cent of the telephone revenue. By the end of 1957 the number of telephones operated by these 15 systems had increased 7 per cent to 4.51 million. There were 1,625,900 telephones on individual lines; private branch exchange and extension phones numbered 1,121,264 and 2-party lines totalled 1,263,700. Pay stations 58,233.

Property and equipment was valued at $1.877 million; revenue totalled $439.5 million or 10 per cent higher than in 1956. Net income amounted to $53.16 million. Employees totalled 61,831, whose wages amounted to $213.8 million.

Next to the Bell system, British Columbia, Alberta, Manitoba and Saskatchewan systems in that order recorded the largest number of conversations, while Avalon Telephone Co. showed the largest number per telephone, followed by Alberta, Edmonton Automatic, Fort William municipal and Manitoba systems, in that order. Bell, New Brunswick, Quebec, Northwest and Okanagan systems were below the Canadian average of 1,766 calls per telephone.

Rate Increase Allowed

At the end of November 1958 the

Federal Cabinet confirmed new rates for Bell service approved earlier by the Transport Board. These went into effect December 1 and are designed to produce $8.6 million of additional yearly earnings.

TELEGRAPH

Perhaps the outstanding development during 1958 was the announcement at the Commonwealth Trade and Economic Conference held in Montreal, of the acceptance, in principle, to proceed with plans for a Commonwealth round-the-world telephone cable system. Canada had submitted some engineering, operating and administration proposals which contributed to the resolution of the many problems involved and the decision to go ahead with such a challenging project.

The first leg of the round-the-world cable will be in service toward the end of 1961 with the completion of a Canada-U.K. trans-atlantic cable engineered to provide 60 telephone channels. The first contract for the manufacture of one major section of this cable was signed in September by C.O.T.C. and Submarine Cables Limited, London, England. This contract, which amounted to 2½ million dollars, covers the 400 mile Gulf of St. Lawrence link between Corner Brook, Newfoundland, and Grosses Roches, P.Q. The engineering and planning of this project continues to be a major activity of the Corporation.

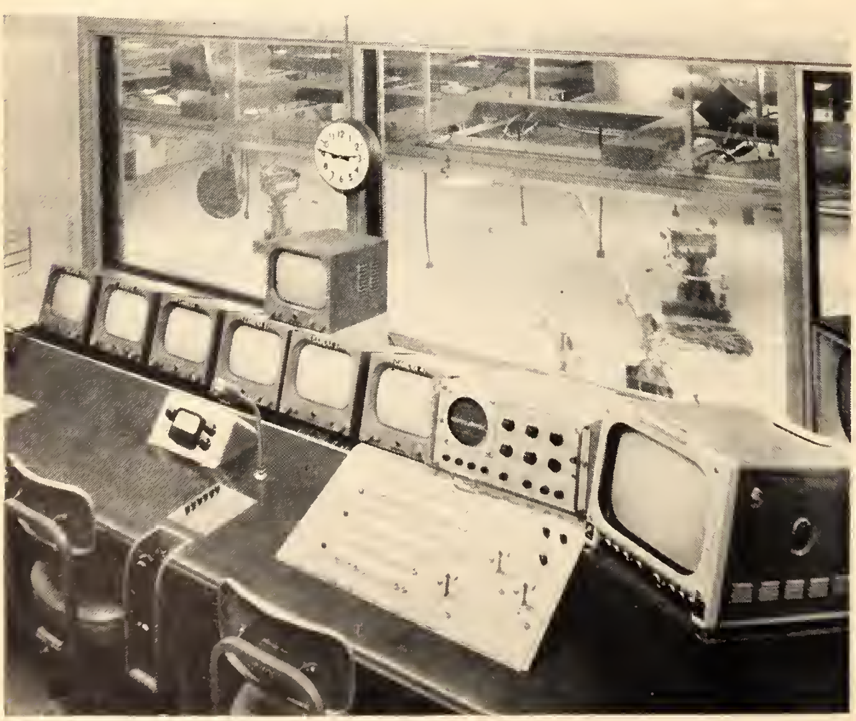
Operating revenues of Canadian telegraph and cable systems in 1957, last year reported in full, rose 10 per cent to $44.8 million from $40.7 million, largely on the strength of sizeable increases in revenues of the Canadian Overseas Telecommunication Corporation and the Eastern Telephone and Telegraph Company. Due to a 16.6 per cent increase in operating expenses however, net income dropped 16½ per cent to $5.304 million from the record high of $6.35 million attained the previous year.

Number of telegrams transmitted reached a 10 year low of 19,163,723, down 6.1 per cent, while messages received from the United States at 2,126,964 were 4.7 per cent under 1956. Number of cablegrams however reached a new high of 2,580,745, 6.2 per cent more than the previous year. Money transfers totalling $25.6 million were 5.3 per cent higher than in 1956.

Total pole line mileage increased 317 miles to 48,375 and wire mileage 8,778 miles to 451,669 during 1957. Major changes were 703 miles of pole line added by C.N.T. and a decrease of 465 miles by Dominion Government Telegraph Service.

A sugar-scoop antennae is hoisted into place along the Trans-Canada Telephone System's microwave network. The 3,900 mile communications skyway was completed by the telephone companies on July 1, 1958.

Montreal-TV studio 42. Video control room view of production desk.



A total of 5,070 offices were maintained for receiving and sending messages compared with 4,934 in 1956. Number of employees engaged advanced to 11,159 from 10,833, while their earnings rose to $37.72 million from $34.7 million. The average annual salary rose to $3,380 compared with $3,204 the previous year.

Of the 11 companies in the group, Canadian National Telegraphs and Canadian Pacific Railway Company between them earn 82 per cent of the total revenue, transmit 99 per cent of the telegrams and 41 per cent of the cablegrams.

RADIO AND MICROWAVES

1958 saw completion of the first Trans-Canada Microwave system, capable of transmitting television programs coast to coast in Canada. The year also saw completion of many of the Tropospheric Scatter Microwave links and other radio linkages serving the northern defence establishments.

HIGHWAY TRANSPORT

In 1957 according to the latest published full report of the Motor Transport industry, there were 2,062 "for hire" freight carriers in Canada, with a total investment of $180.28 million in property, vehicles, etc. Their total revenue rose to $259.06 million that year, compared with $233.5 million in 1956. The average number of persons employed totalled 26,338. Net operating revenue totalled $11.79 million.

Other News of the Industry

Highlights of the Canadian Trucking Association meeting at Saint John in February 1958 included a demand for new legislation on trans-border trucking, and notice that the CTA would continue to oppose the railways' entry into the highway transport field.

In July a start was made on construction of the CPR terminal for Dench of Canada, Ltd., at Edmonton, estimated to cost $250,000 for 12,000 ft. of floor space, with provision for piggyback service. Construction was also started on a $1 million Mack truck centre in Toronto.

Faced with higher operating costs, transport operators will have to increase rates in 1959 to meet them. Wage negotiations between 65 transport firms and the Teamster's Union will add some $10 million for about 7,000 employees. Interprovincial trucking firms have already applied to the QTB for a 17 per cent hoist in rates effective January 1959.

Promising Future for Truckers

A bright future for the industry lies in the fields of bulk tank haul for milk; truck handling of bananas from New York; and tank-truck haul of flour, vinegar, cement, grain, sugar, chemicals and acids. An application has been filed with the OHTB for carrying liquor in glass-lined tank trucks. In addition, truckers stand to benefit from the opening of the seaway.

'Containerization' will help cut handling and distribution costs. This and "piggyback" are fast-growing trends. Truckers are taking a hard look at materials handling costs, and there has been a noticeable change in terminal handling of traffic. A system of trailer interchange, started in Ontario during 1958, is destined to be widely adopted. For truckers in any province operating across the international boundary has come the suggestion for a joint U.S.-Canadian body, through which common transportation problems could be evaluated and solved.

Burlington Bay Skyway, near Hamilton, Ontario, a 4½ mile long elevated highway. This four-lane skyway eliminates a major traffic bottleneck on one of Canada's most heavily-travelled roads.

RAILWAY TRANSPORT

Freight traffic in 1958 for all Canadian railways dipped for the second year in succession, to some 64 billion revenue ton miles, or 10 per cent below the 71 billion ton miles carried in 1957. Passenger-traffic also turned downward after three years of improvement, finishing the year with a total of some 2.5 billion revenue passenger miles, 12 per cent under the 2.925 billion passenger miles of traffic for 1957. Revenue carloadings dropped to 3,750,000 or 7 per cent under the 4,037,381 cars loaded in the previous year.

The year 1958 saw orders for rail cars cut in half from the huge orders placed in 1957 totalling close to 10,000 cars. With carloadings down 7 per cent and earnings squeezed, railways were placing the bulk of their new equipment dollars into completion of their dieselization programs scheduled for completion in 1961. Little change is expected in 1959.

Both of Canada's two major railway systems face a growing problem in the unprofitable commuter service, though the bulk of it is handled by the C.N.R. Efforts to attract off-peak traffic have failed. Equipment and personnel stand by all day for 4 hours, at most, of actual work. Commuters and their local authorities are unwilling to pay more. If fares are upped to pay the cost most commuters will abandon using the service.

Canadian Pacific Railway

Despite a decrease of some 10 per cent in freight traffic in 1958 from the previous year, the Company continued replacement of steam with diesel motive power and was using some 950 diesel units by year's end, doing about 95 per cent of its total rail work with diesels. Further improvements to switching yards, signalling and maintenance of way were made. A four-year contract for relining 1,865 feet of main line tunnel through the Rockies east of Field, B.C. was completed in June. Timber lining was replaced with concrete.

Installation of centralized traffic control was completed from Glentay to Trenton and will be extended to Toronto. The Company acquired control of Smithson's Holdings, Ltd., which wholly owns Smith Transport Ltd., and now owns or controls trucks over almost 10,000 route miles from coast to coast.

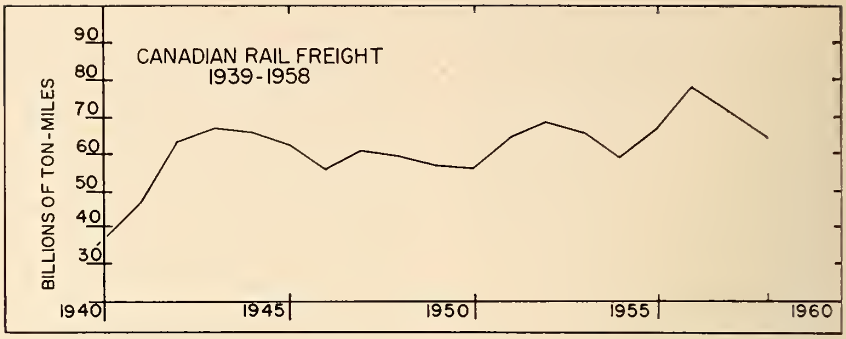
'Piggyback' service was introduced for licensed 'for hire' trucking firms between Montreal and Toronto. This service was extended in 1958 to New Brunswick, to the Lakehead cities and to Western Canada. Plans are underway to extend it to the Pacific coast. Gratifying results were obtained from the wider use of self-propelled 'Dayliners', but increased use of automobiles and buses and improvement of rural highways have all but eliminated passenger traffic on many branch lines.

A two-year dispute regarding the employment of firemen on diesels in freight and yard service, was settled last May. The findings of the Kellock Commission were accepted by both the Railway and the Brotherhood of Locomotive Firemen and Enginemen, modified as to seniority.

Early in 1958 a new subsidiary, Canadian Pacific Oil and Gas, Ltd., was incorporated to assist in development of the Company's oil and gas rights. CPOG has signed a contract for sale of gas to Trans-Canada Pipelines.

In September Canadian Pacific joined with other railways in applying to the Board of Transport Commissioners for a general 19 per cent increase in freight rates, to meet the cost of wage increases recommended by a Conciliation Board. A judgment was rendered in November awarding a 17 per cent freight rate increase. On November 26 an appeal by eight Canadian provinces against the award was disallowed, and the 17 per cent increase took effect December 1.

While ocean passenger carryings by the Company's three liners between Canada and Britain were satisfactory, a world-wide depression in ocean freight rates was reflected in diminished earnings by seven owned and four chartered cargo vessels. A replacement for one of the passenger-cargo liners is on order and when it enters service in 1961, it will be the largest of the fleet. The 'Empress of England' replaced the retired 'Empress of Scotland' as the Company's cruise ship out of New York last winter.



Canadian National Railways

Like other Canadian railways, the C.N.R. felt the impact of general business conditions in 1958 on its traffic in terms of decreased revenue, tonnage and patronage, while costs of wages and materials continued upward. Estimates indicated year-end tonnage figures for revenue freight handled would be down about 10 per cent below 1957, with a loss of 9 million tons compared with 1957. Freight revenues would be down about 8 per cent. Chief decreases were recorded in coal, iron and steel ores and concentrates, autos and parts, pulpwood and crude oil. Increases occurred in vegetables and in lime and plaster.

Due mainly to a 50 per cent drop in immigration and a decline in military movements the upward trend in passenger revenues over the past three years was reversed and showed a drop of 12 per cent from the previous year. Revenues of the C.N.R. telegraphs continued to improve and were further augmented through acquisition of the Northwest Communication System and the Yukon Telegraph Company. Total increase in communications revenue amounted to some 15 per cent.

Nevertheless the Company continued active construction of branch lines. A line from Optic Lake to Chisel Lake in Northern Manitoba will be completed in 1960. In Quebec, tracklaying had been completed on the second 66-mile section between Cache Lake and Lac Chigoubiche. This new line will stretch over 133 miles between St. Felicien and Cache Lake. When coupled to the 161 mile line opened in 1957, between Beattyville and Chibougamau, it will form a 294 mile arc through Northern Quebec which will be opened late in 1959.

Elsewhere new methods, materials and equipment were being put to use to consolidate and improve services. A major speed-up in freight schedules, new equipment and schedules in passenger service, the opening of the Queen Elizabeth Hotel in Montreal, and new communications facilities were highlights of the year's program. Construction was also commenced on a new headquarters building just south of the Queen Elizabeth and Central Station.

Work continued on the huge classification Hump Yard west of the city of Montreal, scheduled for completion in 1961. Another four-year project was undertaken for a new Hump Yard two miles in length outside St. Boniface, Manitoba, across the Red River from Winnipeg. The project, to cover 628 acres with over 100 miles of trackage, will be capable of classifying up to 7,000 freight cars daily.

All train operation in the Atlantic Region and on the south shore of the St. Lawrence west to Montreal is now completely dieselized, as well as most of the operations in northern Ontario, Quebec and British Columbia. By year-end more than 80 per cent of freight train miles were dieselized.

Part of the Frederick G. Gardiner Expressway. Shown are the Humber River bridges, T.T.C. underpass and C.N.R. overpass, constructed by Foundation Company for the Department of Highways of Ontario. The Municipality of Metropolitan Toronto, Toronto Transit Commission and Canadian National Railways, Consulting engineers were Lakeshore Expressway consultants and Canadian National Railways.

Extension of centralized traffic control to the entire main transcontinental line is well underway. Signalling on four subdivisions will be completed by mid 1959, with another five sub-divisions scheduled for complete signalling by early 1960. CTC will be in operation on 40 subdivisions when the program is completed.

Progress continued on establishment of a mocrowave system between Sydney and St. John's for TV and general communication service for operation in 1959.

To find ways of increasing wages while volume of revenue traffic was depressed a general freight rate increase of 3.6 per cent was authorized to take effect on January 15, 1958, but was finally disallowed. Faced with wage increases recommended by a Federal conciliation board a general rate increase of 19 per cent plus 25 cents per ton on coal and coke was applied for. A rate increase of 17 per cent with 22 cents per ton on coal and coke was granted effective December 1st, and a wage settlement was effected with non-operating unions.

Other News

The official opening of the Pacific Great Eastern's northern terminals at Dawson Creek and Fort St. John took place on October 1st, with the inaugural train being operated from Vancouver to the Peace River. Some $80 million dollars had been spent on equipment and track.

Quebec Cartier Mining Co. awarded contracts in September for a 193 mile railway to a point 300 miles north of Shelter Bay on the St. Lawrence. Included in the project will be a huge concentrator for pelletizing up to 8 million tons of iron ore annually, and a 60,000 h.p. power development to provide power. Cost of the project will ultimately reach $300 million.

A matter of lively concern in Alberta at year-end was selection of a route by the Federal government for their proposed $70 million railway to the Northwest Territories, Pine Point on the south shore of Great Slave Lake. Of various routes open for selection the shortest and likely the cheapest would be from McMurray, about 250 miles. But a second possible route is possible from Grimshaw. Just across the Alberta-B.C. border lies the northern railhead of the PGE running from Vancouver which might be a take-off point. Saskatchewan would like the line to start from Radium City. Alberta's claim is expected to have the advantage.

WATER TRANSPORT

Volumes of freight handled in foreign and coastal shipping services at Canadian ports last year showed sharp declines from 1957. Freight handled in the first nine months at 102 million tons was close to 14 per cent lower than the 118 million tons handled in the same period of 1957. Shipping handled in foreign service dropped to 51.2 million tons from the 67 million tons in the previous year. Volume in coast service was steady at 51.2 million tons compared with the 51.5 million tons the previous year for the same period. Though shipments of grain improved 50 per cent over those of past years, movements of iron ore, coal, lumber and petroleum showed sharp declines.

Lake Traffic Sharply Down

Freight cleared through Canadian canals in the 1958 navigation season was also sharply lower. Cargo tonnage through all Canadian canals amounted to 20.56 million tons vs. 36.4 million in 1957, with biggest losses in coal, iron ore, petroleum and iron and steel, partly compensated for by an increase of over a million tons of grains. Tonnage through Canadian and U.S. locks, including the Sault Ste. Marie Canals, amounted to 75.45 million tons compared with 110.8 million tons in 1957. Biggest drop was in downbound iron ore and upbound coal, partly balanced by downbound grains and crude petroleum.

Number of vessel passages through the Welland Canal totalled 8,496 compared with 8,903 the previous year, while vessel passages through U.S. and Canadian locks at Sault Ste. Marie numbered 16,249 compared with 21,044 in 1957. Vessels passing through St. Lawrence canals showed little change at 10,978 compared with 11,282 in 1957.

Ocean Rates

The year 1958 saw ocean freight rates fall to about the same level as they were fifteen years ago—a level where many ship-owners barely covered operating costs. This condition forced many owners to lay up their vessels. Between January and December almost seven million gross tons of shipping was laid up, about 2 million tons of it tanker tonnage. In addition about two million gross tons were broken up.

More Cargo in the North

Canada hopes to handle all waterborne cargo in the Canadian North during the navigation season of 1959, according to Federal Transport Minister George Hees. The United States now handles only one military operation in Canada's Arctic waters, he said. Full support when required has been promised for the $200 million iron ore development at Hopes Advance Bay in Ungava. Backers had requested icebreakers, weather service and navigational aids to assist shipment of iron concentrates via Greenland. More than 100 units of ship-to-shore landing craft have been provided and breakwaters, causeways and beachheads established.

Winter Shipping in the Gulf

That record amounts of cargo will be handled by ports in the lower St. Lawrence and Gulf region during the winter 1958-59, was predicted by the Lower St. Lawrence and Gulf Development Association. In 1957, winter shipments amounted to a total of 19 million tons vs. 3.3 million tons in 1953. By 1970 a volume of 45 million tons is expected —most of the record tonnage expected will be newsprint, bauxite and aluminum ingots. New elevators at Baie Comeau will be in operation by late 1959 and if used on the same basis as those at Montreal, viz. five times their capacity during the year, grain handled could amount to 75 million bushels within a few years or 2 million tons of cargo.

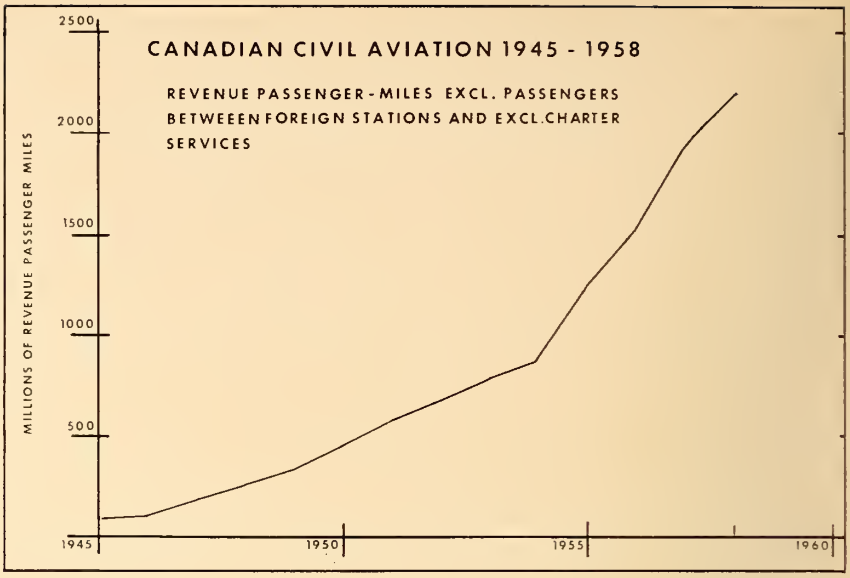
Other News of the Industry

On May 21 the Royal Commission on Coasting Trade recommended in their final report that Canadian ships should not be given any special advantages over those from other members of the Commonwealth.

In October the 8,300 ton auto-ferry William Carson began daily round trips between Sydney and Port au Basques. New piers with freight and passenger facilities were completed at Port au Basques and Sydney. The Sydney freight shed was extended and 250 ft. were added to the shed at Port au Basques.

An experiment at Lakehead ports in December 1958 raised hopes of a slightly longer shipping season and even limited movement of ships all winter. Two ships loaded with 9,000 tons of cement were kept ice-free in the Kaministiquia River during a

25° below zero cold spell with surrounding ice two feet thick. This was the first practical use of a bubbler system in Lake Superior, and cost some $5,000 to install, including $3,000 for an air compressor, $500 for polyethylene piping, $1,000 for electrical service and $500 for labour.



AIR TRANSPORT

THE RAPID GROWTH in Canada's commercial passenger air transport over a ten year period to the end of 1957 continued through 1958, but at a slightly slower pace. Based on reports for the first 9 months of 1958, revenue passenger miles were some 15 per cent higher than in 1957, to a probable 1958 total of 2.20 billion passenger miles. Cargo traffic showed a drop of some 20 per cent during the first half of the year but improved during the second half.

Trans-Canada Airlines

Trans-Canada Airlines, which carries 80 per cent of the nation's domestic air travel and 25 per cent of its air-freight, reported a 17 per cent increase in passenger traffic, to a new record of 1.63 billion revenue passenger miles. Carriage of mail, express and freight for the full year remained at close to the same levels as for 1957, with some 10 million mail ton-miles, 2.5 million express ton miles and 12.68 million freight ton miles.

During the year TCA expanded its activities to meet the heavy demand for air travel, and provided the greatest capacity in its history of more than two billion seat-miles, 19 per cent over that of 1957. Its fleet at year-end numbered 47 Viscounts, 18 other Turbo-props, 11 super-constellations, 21 DC-3's. Four more Viscounts and one super-constellation will be delivered early in 1959. TCA and other IATA carriers introduced an economy class fare for Atlantic travel. Tourist fares were reduced 20 per cent.

By 1961 TCA will become the first intercontinental airline in the world to operate an all-turbine fleet. Construction of a $20 million overhaul and maintenance base was commenced at Dorval to provide service for TCA's future fleet of DC-8 jetliners.

TCA's Atlantic services during 1957 carried 107,054 passengers and handled 243 million passenger miles, 3.86 million ton miles of freight and 1.78 million mail ton miles. This compared with 328.7 million available seat miles and 45.7 million available ton miles.

Canadian Pacific Airlines

CPA, whose domestic air service in Canada is limited to routes of lower traffic density, sought authority in 1958 from the Air Transport Board to fly five transcontinental routes in Canada. In January 1959 the ATB authorized one return non-stop transcontinental flight daily from Montreal to Vancouver.

CPA's Pacific services during 1957 carried 55,914 passengers and handled 215.6 million passenger miles, 3.2 million ton miles and 0.516 million mail ton-miles. This compared with 407.2 million available seat-miles and 42.6 available ton-miles. To its fleet of 8 DC6B airliners, CPA added 6 Bristol-Britannia turboprop aircraft during the year to fly its intercontinental routes.

Ground Facilities and Services

During 1958, Dorval, Malton, Winnipeg and Vancouver airports received delivery in March of Decca MR-75 Shoran Surveillance Radar, while Canadian Pacific Airlines received delivery at Vancouver of its first electronic flight super DC6B simulator. In May, Department of Transport announced $20 million would be spent at Malton for offices and four aeroquays for jet service, in addition to two already built, while a $4 million contract for runways would be completed in 1961. Kelowna would get a 5,000 foot runway.

Very high-frequency omnirange radar installations were announced in July, to be operative between Kenora and Lethbridge, while further sites would be selected in the Maritimes. In August, TCA announced it would receive its first DC8 simulator in September 1959 for installation at its $20 million Dorval overhaul base. With plans for the new passenger terminal at Malton readied and bids to open in December, the facilities there, it was said, would be ahead of anything yet devised for the jet age.

ATB approval was given for TCA to serve Brussels and Zurich in March; in May for CPA to stop at the Azores; in May for Wheeler Airlines to serve Great Whale from Montreal; in August for Nordair to serve Frobisher from Montreal with three flights weekly; in October for Western Pacific and B.C. to amend their services to Prince Rupert and other B.C. airports. Sabena was granted one-stop service from Montreal to connect at New York for flights to Moscow, while Aeroflot will make two flights weekly from Moscow to New York.

Special Flying Services

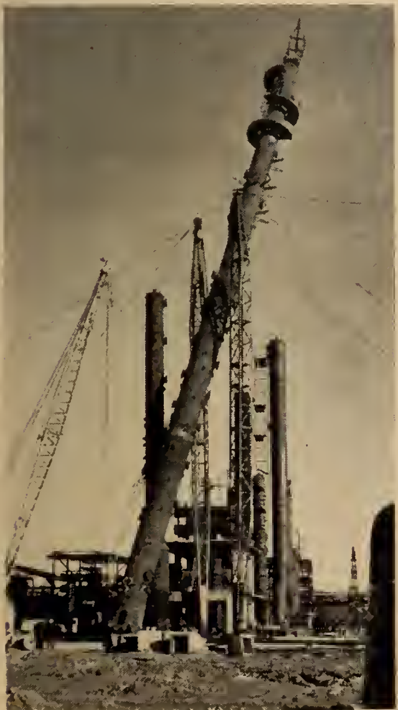
Northern operations, not included in any of the above statistics of nonscheduled services, take in aerial surveys, spraying of forests for budworm control, exploration and geological air surveying for mineral and petroleum resources and special airlifts for construction and mining equipment, rescue and mercy flights and various charter services, such as the servicing of radar station personnel in the northern radar warning lines.

The number of privately-owned aircraft operated in Canada has been increasing rapidly during the past three years, and at year-end totalled 2100.

CONSTRUCTION

THE CONSTRUCTION Industry leads all other industries in Canada in the number of persons it employs and in the value of production. New highs have been recorded in volumes of work done for every year since the end of World War II, though the gain for 1958 over the previous year was only between 1 or 2 per cent compared with the 10 per cent and 20 per cent gains in the two previous years of 1957 and 1956 respectively. Value of construction work performed by contractors at 76 per cent of the total in 1958, remained at about the same proportion of the total volume experienced in recent years.

Erection view of Canada's tallest unit processing tower . . . shop fabricated and field assembled by Horton Steel Works Limited; erected by Canadian Bechtel Limited at Sarnia, Ont.



Approximately 614,000 workers earn about $2.37 billion annually, or a third of the value of work done. They install or use new material or equipment annually worth $3.4 billion. The construction industry's program today represents some 22.3 per cent of the nation's gross national product, compared with 16½ per cent a decade ago.

Annual Report for 1958 based on 'Intentions'

The annual DBS report for 1956-58, containing the most recent statistics available, contains final data for 1956, preliminary data for 1957, and estimates of the intended program for 1958 based mainly on "Private and Public Investment in Canada, Outlook 1958", gathered from a survey undertaken during the previous fall by the Department of Trade and Commerce, revised in June 1958. Preliminary final statistics for 1958 are not published in time to be included in this Review. For 1957, however, the actual figures turned out to be some 4 per cent higher than the 'intentions'. Value of work performed in 1956-1957-1958 by categories, is shown in Table I.

Summaries of investment intentions by sectors of the Economy, as reported by the Department of Trade and Commerce for 1958 and 1959, are shown in Table II. Values of construction performed in each province during 1957-58 are shown in Table III.

As a further, more up-to-date indicator of new work undertaken in 1958, a summary by categories of contract awards during that year for each category of construction, as compiled by the MacLean Contract Guide, appears in Table IV. This statement, issued monthly, shows total cumulative contract awards compared with those of the previous month and year. It is closely watched by the industry as an indicator of trends. Because only three-quarters of all construction is done by contract, however, no record of work done with *day labour* by railways, utilities, communications, industries or governments is included. The annual volume of construction recorded in Tables I, II and III, moreover, includes carry-overs from preceding years, while values in Table IV are total current 'awards' only for the year noted.

Highlights of Building Construction in 1958

Building construction in 1958 showed an increase of some 8 per cent over the previous year. This was mainly due to the 33 per cent increase in housing, though institutional construction was also higher than 1957 by some 10 per cent. Commercial building showed little change, but industrial construction dropped sharply by 25 per cent.

Though the federal building program undertaken the past two years began to slow down through completions during 1958, this was compensated for by the beginning of an upsurge in civic buildings, city halls, provincial government buildings, homes for the aged, city auditoriums and the like. These added to the continuing heavy program for university buildings which will average $20 million over a 10-year period, and the seemingly insatiable demand for schools and hospitals, kept building construction at a high level.

A partial list of the more conspicuous building completions during the past year would include — the Queen Elizabeth Hotel and the addition to Ecole Polytechnique in Montreal; the addition to the Royal York Hotel, Bank of Canada Building and

Confederation Life Building, at Toronto; second men's residence at Queen's University, Kingston; engineering science building at Western University, London; a $7 million tube-mill and a courthouse at Hamilton; and mine buildings and housing development at Elliott Lake.

Notable among new buildings started during the year were the Place Ville-Marie project at Montreal; a 30-storey office building for Prudential Insurance and the 20-storey Trusco Office Building at Toronto; and a chemical and geological survey building for Department of Mines and Technical Surveys in Ottawa.

Continuing under construction were administration buildings for airports at Dorval, Malton, Winnipeg, Halifax and Edmonton, as well as a 13-storey office building for Shell Oil and the Mackenzie office building at Toronto; the Trade and Commerce building at Ottawa; a Sports Centre at Montreal; the T.C.A. Jet Maintenance Base at Dorval, an Exhibition Building at Calgary; the Blooming Mill at Algoma; and the Goodrich Tire Distribution Centre at Toronto.

More than $35 million was spent in the far north for moving the town of Aklavik to the new site at Inuvik and for townsite projects at Forts McPherson, Simpson and Smith.

View of "Mr. Klimax" Marion 7800 dragline with its 35 yard bucket. A truck is parked beside the dragline showing comparative size.

Engineering Construction in 1958

Engineering projects as a whole showed only a moderate gain in volume in 1958 over the previous year. Highway construction at over $1 billion was some 7 per cent higher than 1957; electric power construction, waterworks and sewage, railways and communications, and other engineering showed little change from the previous year; construction of dams and irrigation works showed a small increase. Gas and oil facility construction showed a substantial gain.

Apart from the progress on Canadian power developments (reported in the foregoing section on Power); highway developments by provinces; and the crude oil and natural gas pipelines and Defence Construction projects covered elsewhere in this section, some of the outstanding engineering projects completed or underway during 1958 were as follows:—

Excluding terminal buildings, work completed or under way during the year on clearance, runways, etc., amounted to some $6 million, bringing the total outlay since World War II to a cumulative total of $32 million at year-end on 150 major airports in Canada.

New projects undertaken during the year are listed under 'Civil Aviation'. The objective is to prepare runways for take-off and landings of 150 passenger jetliners.

Bridges

Prominent among bridges were the New Brunswick Island $1 million bridge, started last August; the Burlington Skyway at Hamilton, opened last September; the floating bridge over Okanagan Lake at Kelowna, opened last August by Princess Margaret; alterations to Victoria Caughnawaga, Jacques Cartier and Mercier bridges at Montreal to provide clearance for seaway traffic, substantially completed during the year; work started on the Nun's Island bridge over the St. Lawrence from Verdun to the South Shore; the rebuilding of the Peace River bridge in northern B.C. where piers were completed and a $4 million superstructure contract was under way; the new Second Narrows Bridge at Vancouver, two spans of which collapsed last summer; a C.N.R. bridge over the St. Maurice River; the Autoroute bridge over the Riviere des Prairies; and a bridge over the Exploits River in Newfoundland.

Tunnels

Major tunnelling projects included the four lane, mile-long, $17 million Deas Island Highway Tunnel under the Fraser River south of Vancouver to be opened early in 1959; and the half-mile tunnel under the straits of Georgia on the B.C. coast, successfully blown up in April removing Ripple Rock, long a hazard to navigation; the proposed $201 million tunnel for

Table I—Value of Work Performed by Principal Types—1956-1958

	Actual—1956		Preliminary—1957		Intentions—1958	
	Value $ Millions	% of Total	Value $ Millions	% of Total	Value $ Millions	% of Total
Total Construction	6,389	100	6,702	100	7,136	100
Total Building Construction	3,789	59.3	3,608	53.8	3,873	54.3
Residential	1,830	28.6	1,556	23.2	1,922	26.9
Industrial	594	9.3	568	8.4	423	5.9
Commercial	599	9.4	688	10.3	675	9.5
Institutional	450	7.0	528	7.9	576	8.1
Other	316	5.0	268	4.0	277	3.9
Total Engineering Construction	2,600	40.7	3,094	46.2	3,263	45.7
Marine Construction	128	2.0	173	2.6	155	2.2
Highways—Aerodromes	617	9.7	667	10.0	740	10.4
Waterworks—Sewage	193	3.0	247	3.7	261	3.7
Dams and Irrigation	59	0.9	57	0.8	44	0.6
Electric Power	461	7.2	627	9.4	565	7.9
Railway, Phone and Telegraph	389	6.1	390	5.8	431	6.7
Gas and Oil Facilities	533	8.3	669	10.0	726	10.1
Other Engineering Construction	220	3.5	264	3.9	341	4.8

Table II—Summary of Investment Intentions by Sectors
From Public and Private Investment in Canada—Outlook 1958 and 1959
In Millions of Dollars

	1958			1959		
Total	Construction	Machinery Equipment	Total	Construction	Machinery Equipment	Total
Total	7,230	3,786	11,016	7,021	3,799	11,000
Agriculture and Fishing	174	500	674	174	511	685
Forestry	36	37	73	40	46	86
Mining, Quarrying, Oil Wells	289	161	450	294	142	436
Construction	19	239	258	20	235	255
Manufacturing	508	1,121	1,629	452	1,159	1,611
Utilities	1,676	1,129	2,805	1,480	1,066	2,546
Trade-Wholesale and Retail	222	184	406	242	211	453
Finance, Insurance, Real Estate	162	36	198	218	39	257
Commercial Services	67	161	228	64	164	228
Housing	2,188	..	2,188	2,154	..	2,154
Institutional Services	484	63	547	534	72	606
Government Departments	1,405	155	1,560	1,529	154	1,683

The Craw River Valley Bridge, one of the major building projects on the second half of C.N.R.'s new $35 million Chibougamau branch line.

the Toronto subway, approved last fall but not commenced at year-end. Highway tunnels are also proposed under Mount Royal at Montreal estimated to cost $97 million.

Railway Projects

Completion of Pacific Great Eastern's extension to Dawson Creek and Fort St. John on October 1st was the highlight of the year in railway construction. In September contracts were awarded for a 193 mile iron ore railway 300 miles north of Shelter Bay on the Gulf of St. Lawrence by Quebec-Cartier Mining Co. In Manitoba the C.N.R. was pushing a 52-mile line into base-metal territory at Chisel Lake, 400 miles north of Winnipeg—while in Quebec construction of the second section of the Chigougamau branch from St. Felicien to Cache Lake continued. Pending at year-end was a decision respecting commencement of a $70 million, 400-mile rail extension from Waterways, Alberta to Pine Point, N.W.T., jointly by the C.P.E. and C.N.R. to be assisted by a Federal grant.

In communications, Canada's 3,900 microwave network from coast to coast was opened for operation on July first.

Pipeline Construction in 1958

Canadian pipeline construction in 1958 amounted to some 4,200 miles, for the third largest season in Canadian petroleum history. Completion of the last of the 'big-inch' lines, the 30 inch Trans Canada gas line from Lakehead to Toronto, was the outstanding job in 1958 in variety of problems and terrain, as well as the record number of 12 spreads which worked on a continuous section of 853 miles. With this line in the ground, the basic mainline distribution pattern of Canadian oil and natural gas has been set up, and there can be no more transcontinental pipelines of the same magnitude in the foreseeable future.

Crude oil lines were marked by only two main-line jobs: the Swan Hills-Edmonton line and Interprovincial's four short loops, between them totalling 207 miles of line. The remaining crude oil construction was gathering system work, amounting in all to 375 miles, as shown in Table II. The total of natural gas lines, 3,600 miles, compared with last year's all-time record of 4,300 miles (Table VI).

The outlook for 1959 is for lower volume and much smaller diameters of pipe, since the number of communities remaining to be served along the routes of the main lines is diminishing and the long laterals are mostly laid. However, services for new houses and industrial and commercial buildings in Toronto and Montreal will provide a firm foundation. Some 2,000 miles of gas lines may be laid next year, as well as another 500 600 miles of oil lines.

Head Gates for Beauharnois Hydro-Electrical development, Beauharnois, Que.

Materials

The year 1958 witnessed the virtual elimination of shortages of materials which in the past had hampered construction operations. Material prices however, in spite of the recession, in most instances held at 1957 levels or showed increases.

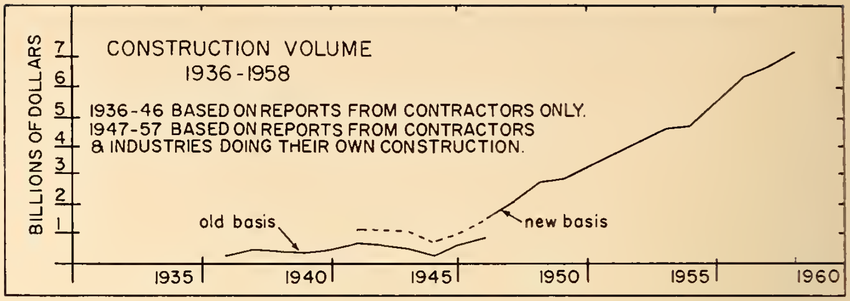
Additions to capacity for materials production over recent years should tend to hold prices steady in the coming year, though labour demands and strikes may result in some price increases.

Lumber prices remained close to the 1957 average during the first half of the year but rose 1½ per cent in the second half; cement, gravel and sand were up 2 per cent; brick, tile and stone prices were lower but gained 1½ per cent the second half; paint and glass showed little change; lath, plaster, insulation, plumbing and heating equipment prices were up slightly; roofing and electrical equipment prices were down 15 per cent and 12 per cent respectively, and other material prices remained steady. The composite price index showed little change.

The demand for laminated 'glulam' timber was maintained, with school, church, and recreation buildings making up for the drop in the industrial building. Total shipments of sawn lumber during first 10 months of 1958 were about the same as in 10 months of 1957. Exports for the same period were up 8 per cent while domestic shipments were some 3½ per cent lower than in 1957.

Bookings of fabricated structural steel held up well, and suppliers foresee an 8 10 per cent increase ahead for 1959, due to enlarged capacity. Advances in welding techniques have reduced weights and saved on erection. Production and shipments of cast iron pipe and fittings were below those of 1957 by 10 per cent and 5 per cent respectively, and of steel pipes, tubing and fittings down 11 per cent and 21 per cent respectively from 1957.

Producers sales of products made from Canadian clays valued at some $40 million were 20 per cent higher than in the previous year, while sales of concrete brick were double, concrete blocks up 25 per cent, concrete pipe up 42 per cent and ready-mix concrete up 33 per cent compared with 1957.



Climate Effect—Research

The effect of Canada's rigorous winter climate on the behaviour and endurance of various building materials is being ably and widely studied and publicized by the Division of Building Research, National Research Council, at Ottawa, established in 1957. The effects of low temperatures on soils, muskeg, masonry, wood products, concrete, plastics, plaster, bituminous materials, paints, and insulation are observed at seven different test sites across Canada.

Trends

Canadian architects are realizing that today's trend is toward more simple exteriors, in better taste than the oppressive over-ornate buildings of the past. The swing is towards acceptance and widespread application of the newer uses of concrete as a building material. Prestressed concrete is gaining popularity in bridges, and in buildings as well, though more slowly. Prestressed members are being produced at reasonable cost.

The lift slab method is gaining recognition, due to savings in forms and shoring costs. Walls are being poured on the ground and tilted into position. This saves on placing reinforcement and on mechanical and electrical work. With another method large *suckers* lift prefab units and deposit them where desired. *Thin-shelled* architectural structures of concrete are making their appearance where scaffolding and forms can be used often to reduce over-all cost. Concrete curtain wall panels are rapidly replacing metal panels.

Coloured buildings too, are gaining favour with architects even at extra cost. Coloured porcelain enamel on a metal base to modernize exteriors of old buildings is finding widespread use due to its weather resistance, though subject to corrosion on a steel base if the porcelain gets chipped. Anodized aluminum, stainless steel with baked-on coatings, ceramic-face glass units, glazed brick tile and ceramic veneer in colours are alternatives, though appearance, as well as comparative costs for installation and maintenance, must be compared.

In heating and air-conditioning, the growth of heating by natural gas is having a sharp impact on boiler, furnace and unit heater selection. On large buildings the trend is towards grouping of temperature control instruments on a large central panel to save legwork. Full air-conditioning installations are fast becoming a 'must' to attract and hold tenants. Wide interest is being shown by home-owners in the plumbing and heating trades campaign to publicize advantages of remodelling older homes for greater comfort, convenience and style in their plumbing and heating appointments. The heat-pump, too, is already finding its place in many homes for heating in winter and cooling in summer.

Another far-reaching trend is the growing use of electronic computers in the construction industry. Already widely used for road and highway quantity calculations, and for stress design on bridges, they are now coming into use for determining the best gradients at which to build the road. Combined with aerial photography they determine the best vertical and horizontal alignments.

For estimating, computers can already correlate cost-experiences, classify them and extract therefrom cost data to be applied to estimating new work. Computer manufacturers predict in ten to twenty years from now the engineer's prime responsibility will be delineation of the problem and the study of the fundamentals.

Table III—Values of Construction by Provinces—1957-58, in $ Millions

Preliminary—1957		Intentions—1958	
Building	Engineering	Building	Engineering
420.7	477.4	408.4	417.1
315.3	392.5	344.5	460.2
146.0	207.7	172.4	200.2
180.9	178.4	185.7	159.7
1,421.3	977.4	1,546.0	1,159,5
894.0	676.8	957.4	678.7
85.7	73.8	87.9	64.9
80.2	62.9	111.6	69.0
8.4	8.3	10.2	11.6
55.1	39.2	49.2	41.9
$3,607.7	$4,094.4	$3,873	$3,263

He will then turn the design, detailing, scheduling, cost control and preparation of the bid over to modern electronic equipment.

The trend to better illumination, both outdoors and in offices and homes, as outlined in the Review published in the Journal issue of April 1958 (p. 94), continues apace. The average lighting level of 10 to 100 foot-candles in 1952 has grown to a range of 100-200 today and is expected to double again by 1968 as lighting technology improves. Westinghouse engineers have revealed a long forward stride in the use of 1,500 cycle power instead of the standard 60-cycle, with power conversion efficiency near 95 per cent at rated load.

Table IV—Contract Awards in 1958—In Millions of Dollars

Province	Residential	Commercial	Industrial	Engineering	Total
British Columbia	104.38	94.35	14.86	56.18	269.78
Alberta	99.69	83.00	5.32	69.73	257.74
Saskatchewan	29.87	35.30	23.53	28.32	117.02
Manitoba	31.11	38.35	8.09	47.28	124.94
Ontario	675.76	429.42	84.51	299.90	1,489.6
Quebec	412.21	364.55	88.21	177.88	1,042.9
New Brunswick					141.1
Nava Scotia	60.18	80.41	24.25	126.93	105.0
Prince Edward Island					10.2
Newfoundland					35.4
CANADA—1958	1,413.3	1,125.4	248.7	806.3	3,593.7
Gain or Loss of 1957	Up 61%	Up 41.5%	Down 37.5%	Down 2%	Up 24%

DEFENCE CONSTRUCTION

Since its establishment in 1950, Defence Construction (1951) Ltd. has completed construction valued at over $1 billion for Canada's national defence. Much of this expenditure has contributed to the development of Canada's north.

In 1958 D.C.L. awarded defence contracts to the value of $90 million compared with $58 million in 1957. The year 1958 opened with uncompleted work outstanding valued at $28.6 million, while work outstanding at year-end was valued at approximately $69 million. In view of the substantial increase in awards in 1959 and the additional work expected for National Defence in 1959, it is anticipated that expenditures on defence contracts in 1959 may be nearly double those of 1958, or nearly $100 million.

Northern Development

As in previous years, 1958 again saw large projects undertaken in the north, such as paving a section of the North West Highway System (Alaska Highway), the construction of the new Peace River Bridge and the large refuelling facilities program at Frobisher, Churchill and other sites. The contract for paving the first 51 miles of the Alaska Highway is nearly complete, while the new Peace River Bridge is expected to be ready for traffic next fall.

Under an agreement between Canada and the U.S. four refuelling bases are being built in Frobisher Bay, Churchill, Manitoba, Namao and Cold Lake, Alberta. Funds for design and construction are being provided by the U.S.A.F. In recent months D.C.L. awarded construction contracts to the value of $25 million for these refuelling facilities. Work is already under way at Frobisher Bay and Churchill. The Frobisher Bay contract was awarded in the amount of $10.8 million. During last summer some 9,000 tons of initial stores were shipped there and work was started immediately.

Air Defence Program

Turning to future defence construction activity—D.C.L. looked forward to participating in a start in 1959 this year on the new aspects of the air defence program, which call for the introduction of Bomarc, *Sage*, and the extension and strengthening of the Pinetree radar control system. The Bomarc guided missile is designed to be used in defence against hostile bombers. The Bomarc missile is an airplane, it has wings and stabilizers and air keeps it aloft. It is guided from the ground with the aid of the same radar system as that used in guiding manned interceptor aircraft. Unlike conventional aircraft the Bomarc is launched from a vertical, tail-down position by the blast of a rocket engine.

Two Bases

It is proposed to establish two Bomarc bases in Canada, to be located in northern Ontario and Quebec areas. Additional Bomarc bases may be located in Canada in the later development of the program, but priority is being given to these two bases. The government decided to incorporate SAGE, or semi-automatic ground environment, in the Canadian air defence system. Expected to be in operation by early 1962, SAGE, an electronic computing centre, will serve as the brains of the air defence system, and will be integrated as part of the North American SAGE system under Norad. The government has also approved the extension and strengthening of the Pinetree radar control system. Several additional large radar stations will be constructed.

Erection of structural steel for engine test house at T.C.A.'s new turbine maintenance and overhaul base at Montreal's Dorval Airport.

NATIONAL DEFENCE

THE NAVY IN 1958

Consolidation of technical training, maintaining increasingly complex naval equipment, armament and machinery and the setting up of a team to study the feasability of acquiring nuclear submarines, were high on the list of R.C.N. activities in 1958. At year-end the Navy had 47 warships in commission, three R.N. submarines under its operational control and a further 6 ships under refit.

Major additions to the fleet in 1958 were two destroyer-escorts, one frigate, 43 CS-2F anti-submarine aircraft, and the last of the *Banshee* jet fighter procurement program. *Banshee* fighters were fitted with the air-to-air *Sidewinder*, while anti-submarine helicopters were fitted to carry homing torpedoes with a kill capability.

A new Naval Technical School was opened at Esquimault, B.C. to serve as a primary source of highly skilled personnel to operate and maintain the increasing amount of technical equipment. Training advances included formation of a cadet training squadron on the Pacific Coast with the primary task of training cadets from service colleges, universities and HMCS *Venture*.

Today's sailor is a technician and specialist. Here a petty officer of the engineering branch operates a throttle valve in the engine room of a Tribal class destroyer escort.

THE RCAF IN 1958

Elements of air Defence Command stood ready on a 24-hour-a-day basis throughout the year to detect and attack any hostile aggressor. Keeping these elements in top operational form were several NORAD exercises.

In September, Prime Minister Diefenbaker announced that an integrated weapons system which includes the *BOMARC* missile and SAGE (semi-automatic ground environment) would be introduced into the Canadian air defence system by 1961. Also approved was the extension and strengthening of the Pinetree radar control system. Two *Bomarc* bases will be built in the general northern Ontario and Quebec areas and others may be located elsewhere in Canada.

Runway barriers were installed at seven Air Defence Command bases in Canada during the year. The barrier will prevent aircraft up to and including the CF-100 from becoming damaged by overshooting the runway on landing.

Overseas, some 6,000 members of Canada's European-based Air Division continued to retain their high operational standard. Simulated combat exercises were carried out during 1958 among the R.C.A.F.'s four fighter wings and with other NATO countries. Canadian aircrews again won top honours from aerial marksmen of other NATO air forces during the air firing competitions at Cazza, Franee.

In July, a ceremony held at Winnipeg marked the closing of the original NATO aircrew training scheme begun in 1950. Final intakes of NATO aircrew personnel were nearing completion of their courses at year-end. Replacing the original plan, training was continuing for limited numbers from Norway, Denmark and the Netherlands. Since the inception of the original scheme, the R.C.A.F. has graduated more than 5,500 aircrew from 10 NATO countries. With the reduction in training, two of the Command's bases—Claresholm and London were closed during the year.

1958 was a busy year for Air Transport Command as its aircraft airlifted nearly 14 million pounds of cargo and more than 70,000 passengers. During the year more than 180 scheduled round trips were made to Europe in support of No. 1 Air Division and the UNEF in the Middle East. In addition, nearly 650 replacement troops were airlifted from Montreal to El Arish and 675 were returned. on special U.N.E.F. rotation flights.

Late in 1957, the R.C.A.F.'s two *Comet* aircraft were put into scheduled Trans-Atlantic service, and since that time have made 28 round trips.

THE CANADIAN ARMY IN 1958

From the four corners of the globe where its members are working to maintain world peace, the Canadian Army looked back at year-end on another year of progress and achievement.

As the year ended Canadian soldiers were serving in Europe, the Middle East and the Far East in support of Canada's increasing commitments to NATO and the United Nations. In June observers were sent to Lebanon for duty with the United Nations Observer Group. Canadian troops serving overseas at year-end totalled some 6,500, the majority with Canada's NATO brigade group in Europe and with U.N.E.F. in Egypt. Late in November all U.N. observers were withdrawn from Lebanon.

At home and abroad the Army embarked on a gradual but general reorganization in 1958 to meet the changing concepts of war and the advent of the *space age*.

The Government decided in October to equip the Army with the U.S. *Lacrosse* surface-to-surface guided missile. A battery of four launchers and associated fire control equipment will be put into service. Half the battery will be assigned to the 4th Canadian Infantry Brigade in Germany while the other will be located in Canada.

The 1st Canadian Infantry Division ceased to exist as an active unit last January, and the field force was reorganized into four independent brigade groups. In line with the new tactical concept that the brigade is the basic fighting formation, the activation of a new armoured regiment was announced in November. Each brigade group in the Regular Army now has an armoured regiment in support.

Planning for the future also gave birth to the Directorate of Combat Development, which will develop new doctrines and techniques and assess these by modern scientific methods.

New equipment introduced during the year included prototypes of the *Bobcat*, a new armoured tracked carrier featuring speed and mobility, essential factors for survival on the atomic battlefield. Amphibious as well as armoured, the vehicle affords complete protection against the thermal effects of atomic explosions and can carry troops across all types of terrain.

Also in the field of nuclear warfare, an Army officer came up with an invention, since adopted as standard equipment by the Army, for a safer, more practical and more economical method of testing the instruments used to measure radioactive fall-out and contamination.

The first full-scale field use of a tellurometer, a battery-powered *echo* timing instrument that accurately and precisely measures the distance between two points, was made in the far north last summer by Army Engineers surveying 60,000 square miles of unmapped tundra. Several other military survey parties, from the Army Survey Establishment, took to the field to help the mapping of Canada.

The Army's communications link with the United Kingdom was boosted in October with the opening of a new 30-kilowatt radio transmitter near Ottawa, equipped with an electronic *memory* device which automatically sets the multitude of controls after a master switch is turned on.

Symbolic of the ground-air co-operation necessary in the air defence of North America is this photo of swift CF-100 "Canuck" interceptors on a sweep over the domes of an R.C.A.F. radar station.

CANADIAN ARSENALS IN 1958

CANADIAN ARSENALS LIMITED, a Crown-owned company whose function is to produce arms and ammunition for the Armed Services, continued to effect improvements in manufacturing techniques.

The Company has nine Plants located in Ontario and Quebec, and among the major production facilities recently installed are the following:

Artillery cartridge cases, previously manufactured from brass, are being replaced by steel cases. The cases are cold deep-drawn and subsequently zinc plated. The plating is performed in a Lasalco plating and chromating unit which performs fourteen separate operations automatically. This unit is located at the Dominion Arsenal Division in Quebec City. Heat treating of the steel cases is also carried out automatically in an Ajax continuous submerged electrode salt bath furnace.

At the Small Arms Division of the Company, at Long Branch, Ontario, extensive use is made of broaching machines in the production of the 7.62 mm FN Rifle*, 12 broaches effecting some 37 operations previously performed on 150 milling machines. This rifle is capable of being fired single-shot, semi-automatically, or fully automatically at 650 rounds a minute.

At the Explosives Division in Valleyfield, Quebec, a program of reconstruction of wartime temporary facilities was proceeded with, and new facilities for the manufacture of rocket grains were completed and brought into production. A building housing crystallizing equipment was used in the manufacture of RDX high explosive. Protection is afforded on three sides by sand-filled timber barricades which are believed to be the highest in the country.

New army personnel troop carrier, "Bobcat".

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*"The F.N. Rifle" *Engineering Journal* of March 1958.

GOVERNMENT WORKS

Federal Department of Public Works

DURING THE FISCAL year 1957-58, latest year for which a record of DPW is available, construction and repairs were done on 263 wharves, breakwaters and other harbour facilities of which 188 were completed. A total of 1,488 smaller projects were undertaken. Dredging was carried on in 328 locations involving removal of 9.5 million cubic yards.

World's largest Waterspheroid, standing 132 ft. above ground level at Red Deer, Alberta.

Contracts for construction of 292 Federal buildings and other premises occupied by Government departments were awarded. Work was still in progress at March 31, 1958, on 122. Construction was started on the DPW administration, the National Gallery and The Finance Building, all in Ottawa.

Expenditures are shown in Table 1.

Sewage and Water Projects

Worthy of mention among sewage and waterworks projects were Metropolitan Toronto's East Don Sanitary Trunk Sewer, completed in 1958; and Montreal's Decarie-Rainbault \$10½ million Collector Sewer, 8½ miles long and 13½ ft. in diameter along Queen Mary Road, to be completed in late 1959. The Conestoga flood control dam in Ontario was completed in January 1958.

In Ontario alone the Ontario Water Resources Commission, set up in April 1957, has already committed itself to \$23 million for construction on behalf of municipalities requesting water and sewer projects. Its objectives are to insure maintenance of safe water supplies and to make it possible for municipalities to finance water and sewer treatment works. Six waterworks and three sewer projects costing \$1½ million are in operation, as well as a 30-mile water supply line costing \$3.7 million from Lake Erie. Under construction are some 25 additional projects which will cost another \$20 million.

Expressways

Among municipal projects for expressways completed or under way were the \$1 million Parkway at Montreal over Mount Royal, opened in September; the 35-mile 80 100 ft. wide Metropolitan Trans-Island Boulevard across Montreal Island, to cost \$31 million over a six year period; The Ontario Highway's Dept. 'Queens Way' through Ottawa; a 6-lane expressway from Vancouver to Blaine, Wash., which passes through the Deas Island Tunnel under the Fraser River; the Don Valley Parkway and the F. G. Gardiner Expressway at Toronto, opened in August.

Highway Construction in 1958

Total road expenditure at all three levels of government in 1958 was estimated by The Canadian Good Roads Association at \$1,044.6 million on highways, roads, streets and bridges—a 7 per cent increase over that of the previous year. Of the total, federal expenditure totalled \$115.66 million, provincial expenditure totalled \$668.97 million (including subsidies of \$86.45 million to municipalities), while municipal expenditures totalled \$260 million in addition to provincial subsidies.

Federal expenditure of $115.66 million was divided as follows: National Defence Northwest Highway System, $10.11 million; Northern Affairs and National Resources, $28.14 million, Public Works, (including Trans Canada Highway Grants) $60.8 million; Federal District Commission, $1.6 million; Railway Grade Crossing Fund, $15 million.

Net current and capital expenditures by provinces in 1958 on highways, roads and bridges, with expenditures on construction only for each shown in brackets, were as follows: in millions of dollars: P.E.I., $4.06 ($2.58); Nova Scotia, $27.28 ($14); New Brunswick, $23.45 ($12.44); Quebec, $150.9 ($106.28); Ontario, $257.58 ($181.43); Manitoba, $35.62 ($4.83); Saskatchewan, $32.9 ($8.71); Alberta, $57.98 ($11.46); British Columbia, $79.2 ($14.74). Newfoundland's budget, not yet approved, was expected to total $10 million.

A breakdown of construction progress for each province during 1958 by categories such as mileages of grading, base course, paving, etc., as reported at the C.G.R.A. Convention in October, was published in the November issue of the Journal under 'Roads Roundup', pages 120-123.

Of the three levels of government, according to C.G.R.A., statistics on municipal road and street expenditure are the least reliable. Previous expenditures prior to 1958 had been substantially underestimated. Efforts now under way will improve the accuracy, but more reliable data is needed on urban road and street finance before a clear picture can be gained.

Highway Traffic Statistics

Vehicles on Canadian highways in 1957 totalled 4,459,595, double the number registered in 1948. Each registered vehicle travelled an average of 8,253 miles in 1957, compared with 7,942 miles in the preceding year. In 1957 all motor vehicles travelled an estimated 36.8 billion miles, compared with 33.6 billion miles in 1956.

Canada's mileage of surfaced roads rose from 131,000 in 1945 to an expected 252,000 miles by the end of 1958. For the first time since World War II there was evidence builders of intercity highways and rural roads were catching up with traffic demands. Urban traffic gets more and more congested however. More than half of Canada's population live in cities, but municipal expenditures amount to only one quarter of the total national road and street budget.

Federal 'Roads to Resources' Program

Of national importance was the Federal governments proposal last year to spend $115 million over seven years on roads in the Northwest Territories and the Yukon. British Columbia, Alberta and Saskatchewan signed agreements with Ottawa last fall under the program. Initial projects commenced in 1958 included the $20 million Cassiar-Stewart Highway, while starts were made by Dept. of Northern Affairs on the Mackenzie Highway from Alexandra Falls to Yellowknife. Construction will start in 1959 on 400 miles in the Yukon from Flat Creek northerly to Fort McPherson and on the Clinton Creek Road northwesterly from Dawson. Several bridges to replace ferries along the Whitehorse-Dawson road were undertaken during the winter.

Government Works

Apart from the many and diverse services performed by federal, provincial and municipal governments, the end-product is in the form of construction of highways, buildings, airports, navigation canals or channels and other forms of public works. Public accounts from the Federal Government and each of the ten provinces are not published until a year or more after the end of the fiscal year.

Capital investment intentions during 1958 by government departments, housing and institutional services, exclusive of Crown Companies, commissions, authorities, administrations and the like, were expected to amount to $3,592 million or 38 per cent of the total Canadian investment, compared with 32 per cent in 1957. Direct government outlays at all three levels of government during 1958, exclusive of privately-owned housing and institutions, were expected to amount to $1,515 million, according to revised forecasts in June 1958, or 17.7 per cent of the total Canadian investment, compared with $1,405 million or 16.7 per cent of the total Canadian investment in 1957.

The total of direct government outlays in 1956, last year for which full statistics of all government expenditure are available, was shown in the Trade and Commerce "Private and Public Investment Outlook" at $1,300 million. Deducting therefrom the $163.5 million spent by the Federal Department of Public Works, including highways, the same year (as shown in detail on Table I) leaves $1,137.5 million presumably spent by provinces and municipalities.

Expenditures during 1956 by provinces and municipalities on highways and streets totalled some $820 million, leaving some $317.5 million spent the same year on other categories of public works and publicly-owned institutions. A summary of public works expenditures from Provincial Public Accounts the same year showed a total of some $150 million for provinces alone. The difference of $167.5 million would thus appear to represent public works expenditures at municipal levels.

Foundation Co. of Canada develops high-speed tunnelling methods without the use of explosives. Start of operation on 11-ft. diameter 2½ mile long Humber Valley Trunk Sewer for the Municipality of Metropolitan Toronto.

P.F.R.A.

The Prairie Farm Rehabilitation Administration, or P.F.R.A., was set up in 1935 during the severe drought and depression years of the 'thirties' to aid farmers in the dry belt of the three prairie provinces. The Act establishing it was amended in 1937 to increase its scope and authority. Its head office is at Regina, with regional offices at Kamloops and Winnipeg and 18 district offices in four western provinces. It is administered through the Federal Dept. of Agriculture. Its two primary functions are water development and land utilization within the 105 million acre area under its supervision.

Larger Irrigation Projects in 1957-58

During 1957-58 expenditures under special votes were: surveys and engineering, $1.77 million; St. Mary River project, $1.62 million; Bow River project, $1.67 million; land protection and reclamation in Manitoba, $337,190; Buffalo Pound project, $440,515; South Saskatchewan project $259,600; Red Deer project, $71,800; construction on other miscellaneous projects, $22,855 and surveys and construction on Assiniboine and Qu'Appelle Rivers, $249,582.

On the St. Mary project the East Ridge Dam and the Belly river division canal were completed. Repairs and alterations were made on a number of works already in operation. Almost 170,000 acres were under irrigation in 1957.

On the Bow River project, enlarging of the original facilities were completed. Capacity of Lake McGregor reservoir was increased. Water was delivered for the first time in 1957 to the West Block of the project, which received 3,073 acre-feet of water during 1957.

On the South Saskatchewan River development sufficient information was gathered in 1957 to permit proceeding with construction. Extensive drilling investigations of site foundations was undertaken and silt sampling and stream flow measurements were continued. At outlook a 171 acre experimental farm to study techniques, practices and crop yields was in operation with water pumped from the river. (Though not noted in the 1957-58 report, agreement was reached in July 1958 between the Federal Government and the Province of Saskatchewan to commence construction of this project on a cost sharing basis.)

No New Trend in Dustbowl

Saskatchewan and Manitoba farmers fear they may be headed for a cycle of drought like that of the 'thirties'. The Red River valley last September suffered the most acute water shortage in 25 years, while around Saskatoon farmers were watering their cattle by tank-trucks. Winter snowfall has been below normal during winter 1958-59. But scientists of the climatological section of the Meteorological service of Canada see no recurrence of the pattern that preceded the dry years of the 'thirties'. Although occasional dry years may come, moisture seems to be getting better instead of worse over the long-haul, they say.

Engineering Services to Foreign Nations

Canada's consulting engineers and architects are continuously designing and supervising new buildings, housing, manufacturing plants, and heavy engineering developments for power, pipelines, airports, smelters and refineries, harbours and transportation facilities. These are translated by Canadian construction firms into the nation's industrial potential at a rate valued at more than $7 billion annually. Here is a vast store of 'knowhow' available to younger nations.

Many Canadian engineers—mining, civil, electrical, mechanical, atomic and chemical, are active as consultants in foreign countries all over the world. Vast power and electric traction systems in such countries as Mexico, Spain, Venezuela and Brazil have been designed and built by Canadians. Brazilian Traction is operated today from Toronto by Canadian management.

In addition to the work being carried out by Defence Construction, Ltd. in commonwealth countries under the Colombo Plan, Canadian general contractors are taking a growing and lively interest in bidding on foreign projects. For example, one such firm is currently installing a 40,000 k.w. nuclear research reactor in India, while another is associated with a local firm which was low bidder on a multi-million dollar hydro-electric and irrigation project in Latin America, in competition with a dozen American and European construction firms. Pulp mills have been designed and built recently by Canadian engineers in thirteen foreign countries.

Canada's trade commissioners all over the world can obtain full information about these projects and the firms which are designing them and carrying them out. A further direct source of information is the Engineering and Equipment Division, Department of Trade and Commerce, Ottawa, Canada.

Canadians are welcomed in foreign lands because foreign nations understand Canada has no political aspirations and no 'strings' are attached to their services.

Table I—Expenditures by Federal Dept. Public Works Fiscal Year 1957-58.
in millions of dollars

	Dredging	Construction and Improvements	Repairs and Maintenance	Staff Sundries	Total
	$	$	$	$	$
Public Buildings	—	55.43	7.28	30.41	99.13
Harbours and Rivers	7.30	21.98	2.99	1.57	33.85
Trans Canada Highway	—	62.20	—	—	62.20
Administration, etc	—	—	—	8.10	8.10
TOTAL 1957-58	7.30	139.62	10.27	46.09	203.28
TOTAL 1956-57 FOR COMPARISON	6.68	104.20	9.88	42.74	163.50

Canadian Engineers in Southeast Asia

The Canadian Colombo Plan Administration of the Department of Trade and Commerce has been endeavouring since its inception in 1951 to assist the commonwealth countries in Southeast Asia with their economic and industrial development. Substantial progress in certain fields has been made by many of these countries, including Pakistan, India and Ceylon, through the assistance given by Canada but a tremendous amount of work remains to be done.

The Colombo Plan Construction Program, which is part of the over-all Plan, is managed by Defence Construction (1951) Limited on behalf of Trade and Commerce. During the past 5 years, through Canadian engineers, contractors and manufacturers, it has supplied Pakistan and India with the complete design and specifications for structures and equipment, as well as construction equipment, permanent equipment, building materials, construction management, supervision, superintendence, training and the technical services necessary to instal hydro-electric developments ranging from 12,000 to 240,000 kilowatt stations, and thermal steam plants of 10,000 to 20,000 kilowatt generating capacity.

They have also supplied similar services for transmission lines and a 300 metric-ton per day cement plant in West Pakistan. In Ceylon, Canadian engineers and contractors have contributed their knowledge and energy to complete successfully a fish refrigeration and by-products plant capable of processing 25 tons of fish every 24 hours.

The total Canadian contribution to the construction program up to the present time approximates $86 million of which approximately $73 million has been committed. A general distribution of the commitments is as follows: engineering services $6 million; permanent equipment $43 million and construction services, including construction equipment, $24 million.

INDUSTRIAL PRODUCTION

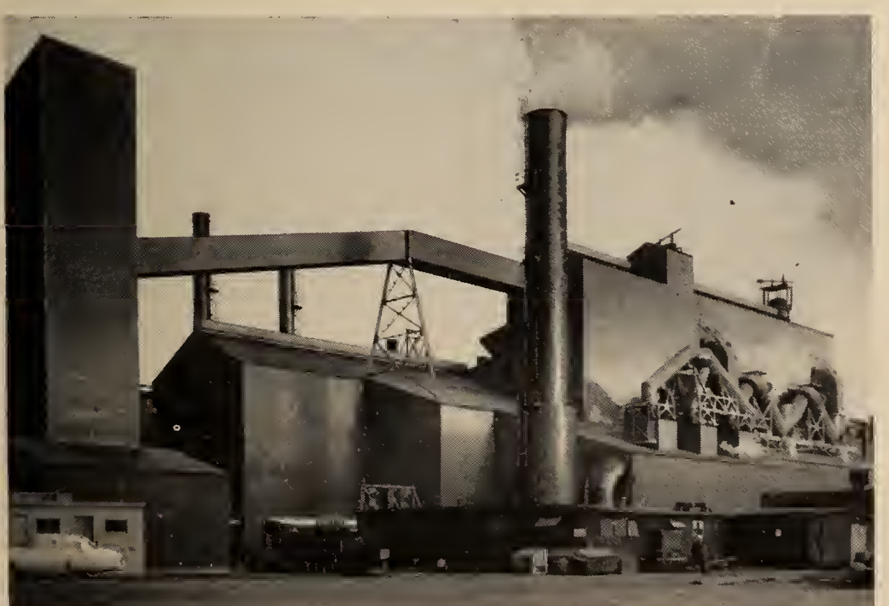
IRON AND STEEL

CANADA'S PRIMARY steel production for the full year 1958, at some 4.25 millions tons of ingot, showed a decrease of 13½ per cent compared with the 4.92 millions tons produced in 1957. Production for the year averaged 73 per cent of rated capacity, in spite of a strike at Stelco, Canada's largest producer, which had dropped total output close to 50 per cent of capacity in September and October. Production of pig iron at some 3.06 million tons for the full year was 18 per cent below the 3.73 million tons produced in 1957.

Canadian steelmakers finished the year at close to 90 per cent of rated capacity, the highest operating level since early in 1957. With orders on hand at year-end indicating a high operating level for the first quarter of 1959 at least, they saw a fair chance of overall domestic demand holding at a high level through most of the year.

Farm implement orders were at a new high level; steel demand for heavy industrial construction programs was strong; demand from appliance manufacturers was improving and the automobile industry showed signs of early recovery. On the other hand, new railway car business was almost at a standstill; while a depressed oil industry and a sharp drop in demand for pipe, casing, etc. had sharply reduced the markets for steel plate.

Two L-D Oxygen Steel-making furnaces at the Algoma Steel Corporation, Limited are housed in the large building shown here. It is equivalent to a 10-storey structure spread over the length of a city block.



Production Statistics for 1958

Of the 3.73 million tons of crude iron ore charged to blast furnaces 75 per cent came from foreign mines and 25 per cent from Canadian mines. Of the 1.78 million tons of sintered or pelletized ore used, 46 per cent came from Canadian mines and 54 per cent from the industry's own processing. Scrap used totalled 132,100 tons. Of the 3.06 million tons of pig iron produced, 429,494 tons was shipped for sale and the balance retained for the industries' own use. Pig iron production averaged 71% of the industry's annual capacity of 4.25 million tons.

Charges to steel furnaces of 4.75 million tons included 2.61 million tons of pig iron, 1.17 million tons of produced scrap and 0.97 million tons of purchased scrap. Of the 4,254 million tons of ingot made, 3.797 million tons was basic open-hearth (including 19,736 tons of alloy steel) ingot; and 0.457 million tons electric. Of the 90,684 tons of steel castings made, 15,971 tons was open hearth, 74,695 tons electric and 18 tons other production.

Disposition of Steel Castings

Based on reports from consuming industries for shipments of the 90,685 tons of castings, distribution was as follows, in tons: exports, 1,545; to automotive industries, 586; agricultural, including farm implements, 1,801; mining, lumbering and quarrying, 14,787; petroleum, 1,187; national defence, 47; public works and utilities, 2,964; railway operating, 17,978; railway rolling stock, 30,523; shipbuilding, 1,255; and miscellaneous, 5,476.

Production during the year of rolled steel products was made up of 3.46 million tons of all hot rolled products, 1.258 million tons of cold rolled products and 114,866 tons of all alloy products. Total shipments amounted to 3.42 million tons, of which 1 million tons was for further processing; 4.71 million tons of carbon products of which 1.47 million tons was for further processing, and 114,947 tons of alloy products of which 93 tons was for further processing.

Disposition of Rolled Products

Disposition of rolled steel products was as follows: in tons: to wholesalers, 319,470; exports, 222,605; automotive industries, 175,200; agricultural including farm implements, 90,238; construction, 601,200; containers, 321,258; merchant trade, 323,095; mining and lumbering, 76,600; defence, 3,710; pressing and stamping, 182,277; public works and utilities, 23,833; railways, 319,000; railway rolling stock, 71,285; shipbuilding, 15,327; pipes and tubes, 461,300; and miscellaneous, 3,044.

Capacity

Iron blast furnace capacity at year-end totalled 4,248,875 tons annually, with 76.3 per cent in 9 furnaces in blast, 16.9 per cent in 4 banked furnaces; and 6.8 per cent in 2 furnaces blown out. Annual steel furnace capacity as of January 1958 at 6,303,000 tons was for ingots; basic open hearth, 4,497,000 tons; electric, 706,000 tons and oxygen, 710,000 tons. Steel casting capacity totalled 390,000 tons.

Activities of the "Big Five" Primary Producers

Steel Company of Canada, Canada's largest producer of ingot, with annual ingot capacity of 2.4 million tons, brought its new number 2 blooming mill into operation at Hamilton early in 1958, raising its total annual rolling capacity to five million tons of steel.

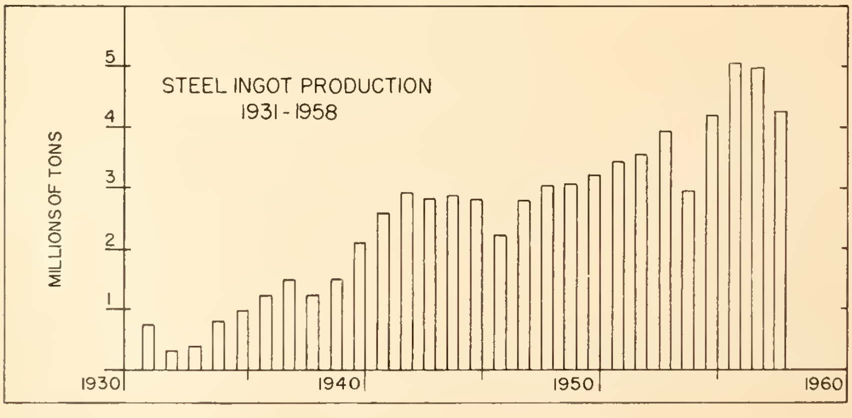
That, however, is double its current ability to produce steel, for to fully utilize the new $25 million plant would normally require as well a doubling of coke-oven, blast furnace and open hearth facilities. Planning in this direction is now under way. Estimates of their costs are difficult to make, but Stelco officials think capital expenditure might ultimately reach a further $1.6 billion.

Stelco officials see no reason as yet to modify their prediction made to the Gordon Commission in 1956, that Canadian steel consumption would double to 14.3 million tons annually by 1980. Assuming some 83 per cent of this to be domestic production, (vs 70 per cent at present) the entire Canadian steel industry would have to double ingot capacity over the next 22 years to about 12 million tons a year.

Algoma Steel Corporation

Canada's second largest producer with capacity of 1.3 million tons is in the final stages of a 10-year modernization and expansion program. Preliminary engineering is complete on a new plant to make heavy structural steel beams up to 24 inch widths on a 75 acre site on the U.S. side of the St. Mary's river. This $25 million project will be carried out in three separate stages over several years.

With completion in 1959 of two new plants—combined blooming and wide-plate mill and an oxygen steelmaking mill, the major post-war expansion costing some $170 million will have come to an end. This ten-year period will show a 62 per cent expansion in Algoma's steel capacity. The existing 600,000 ton operation it started with will also have been fully rehabiliated.



The new ore bridge of Algoma Steel Corporation, Limited has a bucket capacity of 22½ tons, making it one of the largest of its type in existence. Large bucket capacity and the fast operating speed of the bridge have reduced ship unloading time.

Blast furnace facilties have been expanded and modernized. No. 6 furnace has been enlarged to a capacity of 1500-1600 tons daily. Fifty per cent of the greatly expanded coke oven capacity has been built since 1953. The combined blooming mill and wide plate mill will start operation early in 1959. The new plate mill will greatly increase Algoma's market potential in flat products. Long term steel supply arrangements with Mannesmann Tubes, among the most modern pipe mills on the continent built next door to Algoma, has opened a big market for 'tube rounds' for casing. Ingot product in 1958 amount to 961,535 tons.

Dominion Steel and Coal Corporation

For Dosco, Canada's third ranking steel ingot producer with close to one million tons annual capacity, the last big addition was the opening of a sixth open hearth furnace at Sydney in mid-1957, raising capacity from some 700,000 tons yearly to about a million tons.

Most recent capital additions other than the new open hearth furnace include soaking pits at Dominion Iron and Steel, a $4 million plant for Canadian Steel and Graham Nail division in Toronto, a new rolling mill finishing building at Canadian Tube and Steel products in Montreal and a new plant for Canadian Bridge at Montreal.

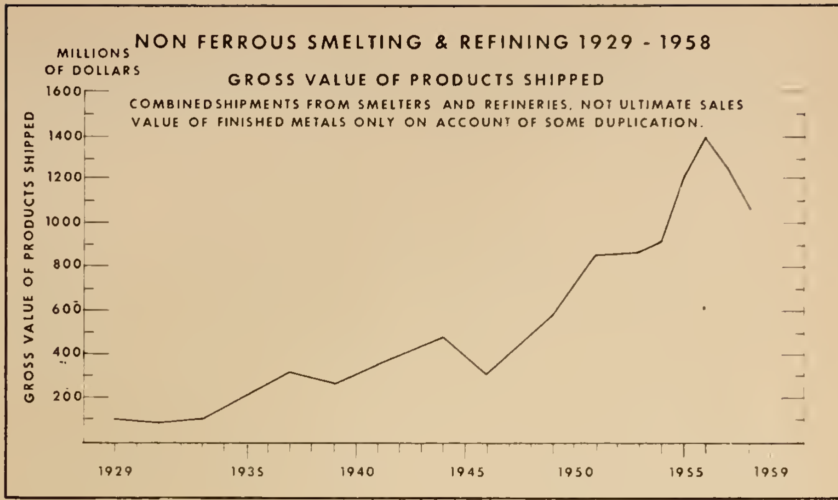
The year 1958 was one of widespread changes. In September 1957 control of the Company had been taken over by A. V. Roe, Canada, Ltd. management reorganization revolved around in the division into four operating divisions:—production, fabrication and manufacturing, mining and transportation. Currently, capital expansion is limited, reflecting the lower steel demand. Tonnage of ingots produced in 1958 has not been reported.

Dominion Foundries and Steel Corporation

Dofasco, with an annual capacity of at upwards 900,000 tons, added 45 coke ovens in 1953, bringing total to 105 ovens and making the company self-sufficient in coke supply. The company also opened its anhydrous ammonia manufacturing plant, built by North American Cyanamid. It is spending $4.5 million on new equipment, including two boilers and boiler house to provide the extra steam needed for the new ovens. Ingot tonnage for 1958 has not been disclosed, but it is expected to be considerably below 1957 production.

Atlas Steels

With annual capacity of some 240,000 tons of specialty steels, operated at about 40 per cent of capacity in February last year, but recovered to 55 per cent of capacity by mid-year. Value of production based on the first 9 months indicated value of shipments for 1958 would reach some $30 million or 31 per cent below 1957. The decline last year was mainly due to reduced requirements of the automobile industry, which accounts normally for half of the company's sales tonnage and 35 per cent of the sales dollar.



Construction of a 3-storey 39,000 sq. ft. administration building, started in October 1957 was completed in June last year, to promote the use of stainless steel for construction in Canada. This steel is produced by Usines Gilson, S.A. of Belgium, a company in which Atlas acquired a 30 per cent interest in 1957.

Other Developments in 1958

Elsewhere in Canada, a start was made last year on a new pipe mill at Contrecoeur, Quebec by Steel Company of Canada. New steel finishing capacity was installed in Western Canada. Construction of a small basic steel mill is being planned by U.S.-Canadian interests south of the St. Lawrence River at Varennes east of Montreal. It will have annual capacity of some 100,000 tons of semi-refined steel. Part of the output will be sold as pig iron with the balance being made into ingots. Capital cost is estimated at between $7 and $12 million, will use the Strategic-Udy process and will be built by Koppers Co., Inc.

General view of the structural steel preparation aisle at Mount Dennis plant. Material is cut, drilled and cleaned in one continuous operation and is then ready for assembly and subsequent painting.

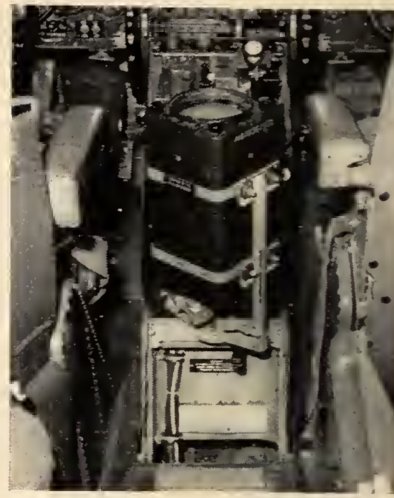
IRON CASTINGS

Production of iron castings, pipes and fittings during 1958 amounted to 691,268 tons or 7 per cent less than the 743,716 tons produced in the previous year. Shipments during the same period at 568,322 tons, however, were only 3 per cent less than 1957 shipments in the same period. Cast iron pipes and fittings alone showed a 2.3 per cent increase, so that the drop in volume was entirely in the area of general castings and castings for use in producers' own plants. The industry covers operations of iron and steel works chiefly occupied in making commercial iron castings or iron and steel pipe and tubing. Some machinery, boilers, engines, stoves and furnaces, etc., were made as secondary or minor products. Some iron foundries have not been included in the Iron Castings Industry, but are classified to other special groups such as manufacturers of agricultural implements, stoves, etc.

SMELTING AND REFINING

The gross value of the output from the Canadian Smelting and Refining Industry in 1958 amounted to some $1.18 billion, down 8 per cent from production the previous year valued at $1.28 billion. This was due largely to the lower production of base metals from Canadian mines.

The industry includes only firms engaged primarly in the smelting of non-ferrous ores or concentrates and in the refining of metals recovered therefrom. The smelting of imported ores is included. Secondary smelters, which treat scrap metals, are not included. The list of metals covered includes copper, nickel, lead, zinc, aluminum, magnesium, titanium, molybdenum, tungsten, cobalt, antimony, bismuth, cadmium, selenium, tellurium and precious metals.



The weather radar scope in Trans-Canada Air Lines' Super Constellation aircraft.

BRASS AND COPPER PRODUCTS

Shipments by the Brass and Copper Products Industry during 1958 were valued at some $163 million, about 12 per cent less than the value of shipments the previous year of $179.2 million, and 33 per cent lower than the shipments in 1956 valued at $244.1 million.

In 1956, according to the latest full report available 108 foundries and 46 fabricating plants reported under this industry. Total employment stood at 9,220; 5,368 persons in Ontario, 2,952 in Quebec; 560 in Alberta and New Brunswick; 191 in British Columbia and 149 in Manitoba. Wages and salaries paid totalled $34.73 million, fuel and power cost $2.4 million, materials used cost $173.6 million, value added by manufacture totalled $69.5 million, and gross selling value of products amounted to $244.1 million. Ontario plants accounted for 55 per cent of the output and Quebec plants for 40 per cent.

ALUMINUM PRODUCTS

The year 1957-58 witnessed a change for the aluminum industry, with strong demand and rapid expansion of capacity being succeeded by over-supply and keen competition. Aluminum Co. of Canada's 620,000 ton annual capacity in the Saguenay and Kitimat areas, which operated at full capacity in 1956, was cut back to some 590,000 ton rate of output in two stages during 1957-58. Production rate was again cut back at the end of 1958 for a third time, to 500,000 tons yearly.

Apart from some 90,000 tons of ingot used in the Canadian aluminum products industry, production of ingots from both companies, Alcan and CBA, is exported. Alcan's Canadian market for products is improving, and consideration is being given to enlarging its rolling capacity at Kingston. CBA is participating jointly with Phillips Electrical Co. at Brockville in building a cable mill, while Alcoa may also enter the Canadian fabricating industry. Best gains are expected in sales of aluminum sheet.

Installation on B-47 Aircraft for Iroquois engine flight-test. Designed and built by Canadair Limited.

THE MACHINERY INDUSTRY

Based on preliminary reports for the first 10 months of 1958, value of shipments by the industrial machinery industry fell about 25 per cent below the value of shipments in 1957, and was 42 per cent lower than the value of $471.2 million shipped in 1956.

In 1956, latest year for which a full report is published, there were 414 establishments employing 37,520 persons, 23,000 of whom were employed in Ontario and 11,000 in Quebec, and who earned $142.1 million. Fuel and power cost $4.33 million and materials used cost $213.15 million. Valued added by manufacture was $274.4 million and gross selling value totalled $471.2 million. Values of production for some of the principal items manufactured were as follows: conveying and materials handling equipment $50 million; construction machinery and parts, $46 million; compressors and pumps, $31 million; engines and parts, $25 million; pulp and paper industries machinery and parts, $25 million; transmission equipment and bearings, $22.6 million; and all other products $271.6 million.

FARM IMPLEMENTS

This industry covers only firms which produce agricultural implements as their main product. Some other firms in other groups produce implements as a major part of their production, but are excluded from farm implement statistics on employment and value of products. Preliminary reports of shipments during 1958 indicate an increase of some 35 per cent over the previous year, to a value of some $150 millions.

Sales of farm implements and equipment in 1957 to Canadian customers, including imports but excluding exports amounted to $149.3 million, a 12.6 per cent decrease from the previous year. This value is at wholesale prices, and an estimated mark-up of 20 per cent should give a reasonable figure for dollars spent by farmers, according to the industry. In 1957, tractors, haying and harvesting machinery were the major lines responsible for the over-all decline in sales.

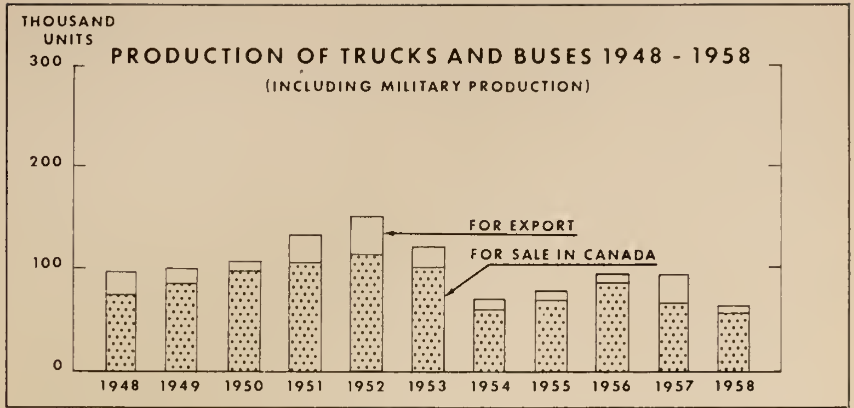
MOTOR VEHICLES

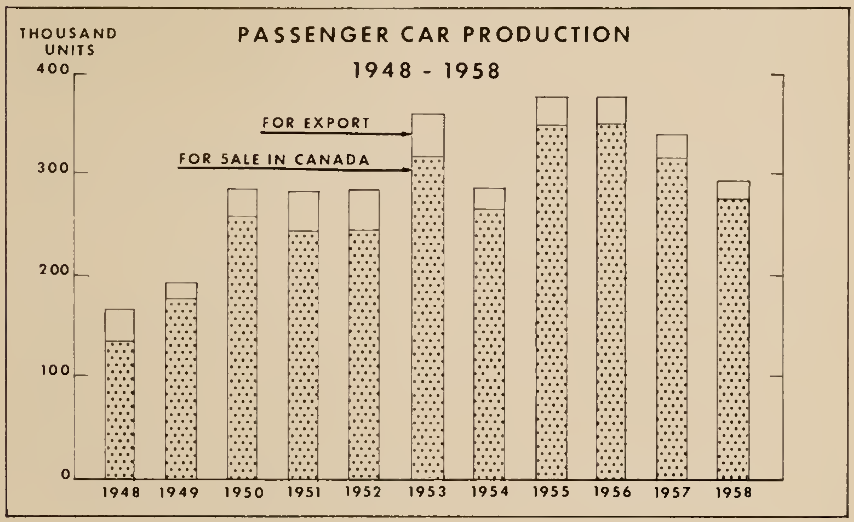
Canadian production of motor vehicles in 1958 at 355,465 units was 12½ per cent below the 411,492 vehicles produced in 1957. Passenger car production at 297,025 was 12 per cent lower and commercial vehicle production at 58,370 was 18½ per cent lower than in the previous year.

Factory shipments of made-in-Canada passenger cars at 298,344 units and Canadian-made commercial vehicles at 61,281 units were 12 per cent and 15 per cent respectively below shipments in 1957. Slightly more than half the commercial vehicle shipments were those maximum gross vehicle weight of 6,000 lbs. and less. During the last quarter, however, sales exceeded production by some 15,000 units.

Standing of Manufacturers

General Motors of Canada was the leading producer in 1958 with 158,712 vehicles, followed by Ford of Canada with 89,267, Chrysler of Canada with 44,131 and Studebaker of Canada at 4,514. Sales of British and European cars in 1958 at 69,439 passenger cars and 6,116 commercial vehicles accounted for 18.7 per cent of the total volume of Canadian sales. This compared with 11.9 per cent in 1957 and 8.4 per cent in 1956.





RAILWAY ROLLING STOCK

Sales of railroad equipment in 1958 to Canadian railways by the 30 firms which produce it were valued

Table 1 Canadian Ship Launchings 1958

NAME	TYPE	DIMENSIONS	CAPACITY	LAUNCHED	OWNER	USE
A. T. Cameron	7,500 mile range	177′ x 32′		Sorel—April	Federal Government	Fisheries Research
Rockliffe	Motor vessel	259′ x 43′	137,330 bus.	Lauzon—April		
Saguenay	MV Ferry	150′ x 37′	21 cwt. 200 persons	Lauzon—April	Gulf Ports Stp. Co.	L'Anse au Portage-Tadoussac
Sunrhea	Motor vessel	550′ x 67′		Lauzon—April	Saguenay Shipping	Grain & Bauxite
Fort Steele	Patrol cruiser			Kingston—June	R.C.M.P.	Patrolling
Fort York	Canaller	462′ x 56′	330,000 bu.	Collingwood—June	Canadian Stp. Lines	Package Frght. onG.L.
North Voyageur		185′ x 36′	51,000 c.f.	Lauzon—June		all weather shipping in Gulf
Tyee Shell	Tanker	259′ long	13,000 bbls.	Collingwood—July	Shell Oil Co.	Tanker to serve G.L.
Nipigon Bay	Tanker	620′ long	18,000 tons	Port Arthur—July	Pipeline Tankers	Converted to 2 bulk car.
Avery L. Adams	Motor Vessel	578′ x 72′		Montreal—July	Panama Pac. Tankers	
Alexander Henry	Icebreaker	210′ long		Port Arthur—July		
Frank S. Sherman	Bulk carrier	681′ long	22,000 tons	Pt. Weller—December	St. Law. Transport Co.	Grain & Coal
"Sir Humphrey Gilbert"	Comb. Ice Breaker and Buoy Vessel	211′ x 48′		Lauzon—November	Dept. of Transport	Navigation Aids
Tyee Shell	Tanker	249′ x 39′	75,000 c.f.		Shell Oil C.o	
HMCS Lacroix	Restigouche Type destroyer			Sorel	Canadian Navy	

at some $342 million or 11% below the value of shipments made in 1957, the best year the industry ever had, and 1 per cent below the value of shipments in 1956.

In 1957, the most recent year fully reported, 30 establishments employed 27,909 persons, 12,649 of whom worked in Quebec, 5,959 in Ontario, 4,822 in Manitoba, 2,635 in the Maritime Provinces and 1,844 in Alberta and British Columbia. Total earnings amounted to $104.16 million; fuel and power cost $4.42 million; cost of materials used was $241.83 million; valued added by manufacture was $140.47 million and gross selling value of products was $386.72 million.

The number of various types of equipment produced were as follows: passenger cars, 25; box cars, 5,169; gondolas, 1,050; flats, tank cars and refrigerator cars, 497; all other types of freight cars, 3,734; all valued at a total of $99 million; standard gauge diesel-electric locomotives, 521, valued at $94.4 million; forgings, castings, brakes and shoes, and repair work, $155 million; all other products including value of uncompleted cars after deducting during 1957, $42.1 million. Imports during the year were valued at $29.8 million, while exports were valued at $12.8 million. Most of the equipment was a carry-over of orders placed in 1956.

SHIPBUILDING

The year 1958 was a disappointing one for the shipbuilding industry. The report of the Royal Commission on Coasting Trade, made public in May, recommended that marine industries in Canada should be dispensed with rather than helped. In addition, there was a scarcity of orders placed for commercial vessels. Production activity was centred on the fitting-out and completion of the remaining destroyer-escorts in the 14-ship RCN program commenced eight years ago. The last four are due for completion in 1959; one each in February and June and the final two in November. Four service ships were built for the Federal Government and some fifteen commercial vessels, as shown in Table I.

The level of employment in the shipyards is steadily falling and further declines are expected. The 15,000 production workers employed at the peak of the naval program in 1951-52 had dropped to some 10,000 by year-end. However, orders were placed early in 1958 for six new vessels at a cost of $10 million and for conversion of two wartime tank-landing craft for carrying cargo to DEW line sites in the Arctic. In November, Defence Production Minister Raymond O'Hurley announced allocation of six new destroyer-escorts for the RCN, for completion in 1962-63

AIRCRAFT AND PARTS INDUSTRY

The year 1958 saw a falling off in aircraft production from the value of production of $424.44 million reported for 1957, the record peacetime high in value of production. Though figures are not available for the year, industry leaders have estimated a drop of some 5 per cent below 1957.

The industry's third largest manufacturing group in terms of employment and ninth in terms of sales, is subject to many rapidly-changing factors which make predictions for the future difficult. Its prospects will depend on implementation of a production-sharing agreement for defence equipment with the United States.

Achievements in 1958

As a year of achievement by the Aircraft industry, 1958 had some outstanding highlights; the first flight of the *Arrow* on March 25;** completion of Belgium's order for 50 Mark CF-100: full production by Canadair of the CL-28 *Argus* Maritime Reconnaissance aircraft continued, with about half the order completed; commencement of production for the CL-44 military transport, with expected follow-on with CL-44C Canadair Liner; completion of *Sabre* production at Canadair in October, with a total of 1,815 produced; and a production line started for the CL-66, turbo-prop version of the former piston-engined Convair 440 liner, with its derivative the Canadair 540 which will follow.

The end of July saw the first flight of DeHavilland's *Caribou*, while production continued on *Beavers* and *Otters;* and CS2F-1 Trackers were still being assembled for the Royal Canadian Navy. Canadian Pratt and Whitney continued production of engines and overhaul of Sikorski helicopters; Rolls Royce of Canada extended facilities for overhaul of "Dart" turbo-props, while turboject-powered DC-8's and Vickers Vanguards will be going into service with TCA. Bristol Aero-Engines (Western) Ltd., opened new facilities for overhaul and repair of CPA's "Bristol Proteus" turbo-props.

Though the missile field did not enjoy an encouraging year, the *Sidewinder* is being carried as armament on RCAF Navy *Banshee* jets purchased from the United States. Late in the year it was announced an order had been placed for *Marten Lacrosse* short range ground-to-ground missiles for the Canadian Army.

**Production of The CF105 "Arrow" was discontinued in February 1959.

ELECTRICAL MANUFACTURING

Preliminary estimates indicate the 1958 output of Canada's electrical manufacturing industry will have a value of some $1.13 million, 7½ per cent below the production during the previous year valued at $1,222 million. The heavy capital goods section or apparatus division of the industry had a sharply reduced volume of new orders from the nation's utilities and industries. Spending emphasis in the appliance field showed an increasing trend towards soft goods and services, and away from such durables as electrical appliances.

In the electronics section, sales of consumer products such as radios and TV sets held up well, during the first half year, though decreased demand in the second half resulted in a drop of some 10 per cent below that of the full year of 1957.

In the engineering products sector of electronics, defence orders continued to fall off for the second year. Commercial requirements of engineering products during the first half of 1958 almost equalled demands for defence. But at the year-end the engineering section found itself in a state of "suspended animation". This was largely due to government decision to abandon the Astra five control system for the CF 105 Arrow, and to a delay in orders for commercial requirements for communications system, until needs for circuits for purely defence purposes are determined.

Demand for Apparatus

At the end of 1958, Canadians had available to them a total of 26,154,-000 horsepower of electrical generating capacity, an increase of 2,736,-000 horsepower or 8 per cent over 1957's year-end figures. This augurs well for the long-term future, for it indicates the confidence of the utility industry in having available generating capacity to meet the anticipated demand for more and more electrical power.

It is recognized that utilities and heavy industries—the consumers for apparatus—cannot expand on a balanced incremental basis year by year. It appears that the apparatus segment of the electrical manufacturing industry can look for no rapid upswing in demand for its products over the next 12 months. The trend points toward a five-year apparatus segment unless distracted by international emergencies.

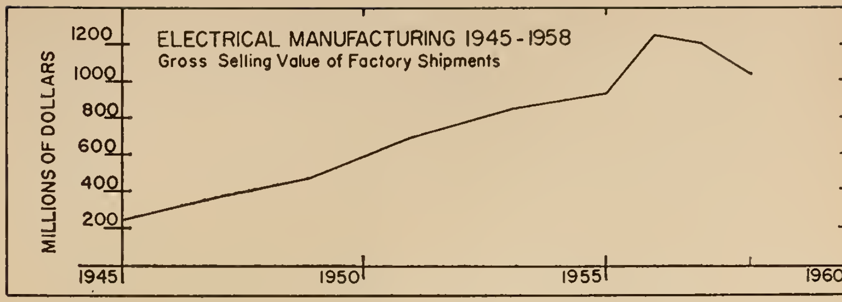
While high Canadian wage rates militate against the industry in many of its product lines, leaders in the Industry believe that certain types of Canadian-built electrical apparatus could compete successfully in the export market. Export sales in these products have been lost over past years, however, due to lack of a Canadian equivalent of the extended credit terms offered by government-supported agencies in the United States, Britain and West Germany.

Representations were made last year by the industry to the Federal government, asking for the establishment of export-import banking facilities to make available to Canadian exporters credit terms and conditions equivalent to those in the countries against whom the industry is competing.

The Appliance Market

Industry sales of major appliances during 1958, showed more pronounced strength in the second half of the year than in the first. While refrigerator and television set sales were down 5 and 10 per cent respectively, the increases in industry sales of ranges, wringer washers and automatic laundry equipment (up 9, 8 and 15 per cent respectively) more than offset these declines and produced a total increase for this group of consumer goods of some 2 per cent. This picture was in sharp contrast to the major appliance market in the United States where 1957 was a poor year and 1958 a worse one.

Much of the strength in appliance sales and consumer goods in general can be traced directly to Government monetary policy and its effect upon the housing program.



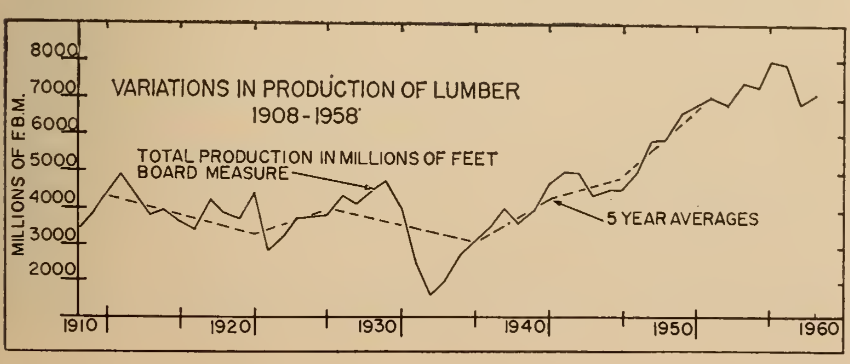
Lighting

Electric lighting in all of its many uses in modern electrical living showed continued progress during the year, and promised significant advances in the future. While the year's progress in light source developments were reviewed at The National Technical Conference of the Illuminating Society in Toronto, the most important report was the presentation of the findings of researches through the ten years on the quantity of illumination needed for every day seeing tasks in commerce, industry, and the home.

On the sound scientific basis of these studies, technical committees of the Illuminating Engineering Society are preparing new recommended footcandle values, substantially higher than those formerly used. In some cases the new values are two to three times the old. The putting into practice of these higher recommended footcandle values will greatly increase the amount of electricity used for lighting.

There is better lighting in Canada's new office buildings, factories and shopping centres. Fluorescent lighting continues to forge ahead. A recent development which has contributed to this is the introduction of the Power Groove fluorescent lamp, with a wattage rating as high as 200 watts.

Developments have been introduced which contribute to greater safety on our streets and highways. The four-lamp headlight system used on new cars has greatly improved night driving visibility. On streets, there has been a distinct trend to fluorescent lighting; the result is better lighted streets with far less glare.



Electronics

Canada's electronic equipment industry is continuing to show every sign of growing into a full-fledged giant. A large part of electronic equipment business is devoted to defence, but the commercial electronics business has also gone through rapid expansion.

In the commercial electronics field, controls for automation of factories and industrial processes will take a major share of future electronics expenditures. Companies within the industry have continued to carry out investigations of the Canadian market potential for computers and industrial television, with a view to full-scale entry as soon as economic circumstances are favourable. Some of the brightest prospects for the industry lie in these areas, along with general communications and industrial control systems.

The recent changes which have taken place in government control of the broadcasting industry should serve to increase demand for broadcasting equipment which decreased in 1958 as a result of the slowing down of the issuing of licenses. While industry volume of mobile radio was reduced in 1958 due mainly to reduced investment in capital equipment, the new Department of Transport regulations permitting increased use of two-day mobile radio by business vehicles should continue to have a stimulating effect over the next few years.

Nuclear Power

Developments in the field of electric power generation from nuclear sources continued to attract world-wide attention in 1958. The year saw a trend toward concentration on fewer reactor types. Britain continued work on several large nuclear power stations using graphite moderator and natural uranium fuel. The U.S. will concentrate on the three reactor types. Canada's efforts continue with the heavy-water moderated type of reactor which she has pioneered. These moves to concentrate effort and experience should hasten the advent of economic nuclear power.

The heavy-water moderated reactor still appears to be by far the most suitable type for economic application in large central stations in Canada. The major advantage of this type of reactor is its low fuelling cost, combined with freedom from the need for chemical reprocessing of spent fuel to recover unused uranium 235 and plutonium. The fact that large supplies of natural uranium are available in Canada and other countries is also of great importance. Enriched fuel on the other hand is, in the main, obtainable only from the U.S. with attendant political and price controls.

There are several important areas in Canada (e.g. southern Ontario) in which nuclear power should become competitive within the next 5 or 7 years. There are few undeveloped waterpower sites available within economic distance of the large load centres.

The year saw formation by Atomic Energy of Canada Ltd. of a new division known as the Nuclear Power Plant Division, to help advance development of nuclear power to a stage at which the utilities and industry can continue development on a normal commercial basis.

Progress on Canada's Nuclear Power Demonstration Reactor (NPD) has been excellent. Construction activities were resumed last summer, and with rock excavation completed, the building substructure is now being poured. This 20,000 kw prototype plant will be commissioned early in 1961. There is no doubt that experience with NPD will prove incalculable for Canada's power reactor program as well as contributing generally to reactor technology.

CEMENT AND CONCRETE PRODUCTS

Canadian manufacturers of Portland cement during 1958 produced 6,316,569 tons or 1½ per cent more than the 6,248,718 tons produced in 1957. Shipments during 1958 at 6,157,817 tons were also 1½ per cent higher than those in 1957.

Concrete Products

During 1958, concrete products shipped (with comparative quantities shipped in 1957 for each item following in brackets) were as follows: concrete brick, 136.6 million (94.1 million); cinder concrete blocks 13.4 million (9.75 million); haydite and slag concrete blocks, 19.8 million (17 million); concrete chimney blocks, 724,900 (834,669); cement drain pipe, sewer pipe, water pipe and culvert tile, 669,676 tons, (453,225 tons); ready mix concrete, 6,520,134 cubic yards, (4,966,161 c.y.).

GLASS AND PRODUCTS

Factory shipments of glass for 1958 are not recorded separately by months. For this reason no records for 1958 are available. Though it is doubtful that glass shipments in 1958 greatly exceeded the $90.8 million value recorded for 1957, the flat glass section of the industry experienced its best year to date, mainly due to record housing construction.

In 1957 factory shipments at $90.82 million were 4.3 per cent higher than in the previous year. Imports were valued $47.9 million compared with $50.4 million in 1956. Exports totalled $1.15 million compared with $1.5 million in 1956.

CLAY AND PRODUCTS

The clay products industry is divided into two sections for statistical purposes. Production from domestic clays, including building brick, structural drain and roofing tile, stoneware, sewerpipe, pottery and refactories, in 1957 came from 119 plants which employed an average of 5,700 persons, whose earnings amounted to some $13.8 million. Process supplies cost some $1.03 million and gross selling value amounted to $34.9 million. Ontario plants accounted for 27 per cent of the total employment. All provinces except Prince Edward Island produce clay products.

Production from imported clays includes electrical porcelains, sanitary ware, sewer pipe, tableware, artware, floor and wall tile, and fire clay blocks and shapes. Production in 1956, last year for which full data are available, came from 37 establishments employing 2,131 persons; 1,200 in Ontario, 744 in Quebec, 162 in Alberta and British Columbia. Net value of production was $14.2 million and gross selling value of products amounted to $20.95 million.

THE LUMBER INDUSTRY

Production of lumber in Canada during 1958 at some 7.017 billion board feet showed an increase of about 1.4 per cent compared with the 6.76 billion feet produced in 1957. Production in British Columbia showed an increase of some 550 million feet, while in the rest of Canada production dropped by some 300 million feet.

During the first ten months exports, which represents about half of production, were about 6 per cent higher than for the same period in 1957. About 80 per cent of these exports were to the United States, compared with the 40 per cent that went to the U.S. ten years ago. Only 12 per cent of exports went to the United Kingdom and 6 per cent to other Commonwealth countries, however, compared with 40 per cent and 12 per cent respectively ten years ago. This would indicate that the industry is not doing enough to encourage exports to other countries.

In the domestic market the use of lumber was greatly influenced by increased government spending and by the sharp increase in housing construction.

The mills range in size from the giant mills on the Pacific Coast, cutting up to half a million board feet per shift, to the small mills which only turn out a carload of lumber in ten days. The larger mills are concentrated around Vancouver, New Westminster, and the lower mainland of British Columbia as well as on Vancouver Island, along the Ottawa Valley, Georgian Bay, Rainy River, and the Coast of New Brunswick.

MINERAL RESOURCES:

THE YEAR 1958 was another encouraging one for Canada's mining industry as a whole, in spite of the troubles facing many of its segments. The total value of production for all minerals, including petroleum, at $2.12 million was 3 per cent below that of the previous year's value of $2.19 billion. Improvements during the last half-year made the outlook brighter than had seemed possible at mid-year for many of the leading minerals.

Iron Ore

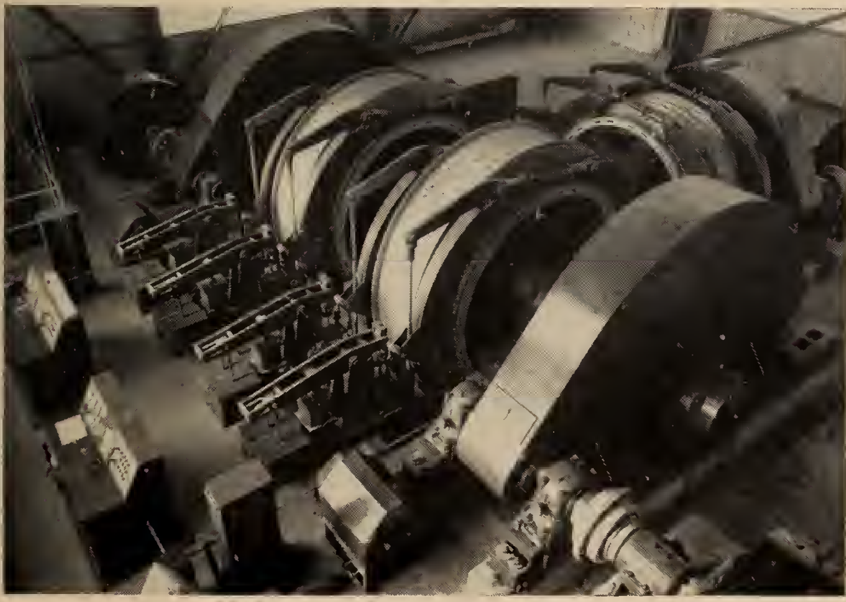
Canada's production of iron ore amounted to some 16 million tons, compared with slightly over 20 million tons in 1957 and 22 million for 1956. Since productive capacity far exceeds the 6 million tons of Canada's ore consumption, the bulk of output must be exported, and in 1956 more than 80 per cent of exports went to the United States. Last year U.S. imports of Canadian ore dropped to around 8 million tons, reflecting the sharp drop in U.S. steel production resulting from the recession.

Newcomers in 1958 were Hilton mines in the Ottawa Valley and Canadian Charlson near Steep Rock, both of which will ship concentrates. Hilton has a capacity of 600,000 tons of pellets yearly while Charlson's capacity is 25,000 tons yearly from Haematite bearing gravels.

Elsewhere, Iron Ore of Canada will show a production of some 8 million tons for 1958; Steeprock, though output was sharply reduced, is gearing ing for a steady annual production of 5½ million tons. Algoma Ore Properties set a new record in 1958 and expects to turn out 2 million tons of highgrade sinter in 1959 from its enlarged plant; Caland Ore near Steeprock will not be in production before 1960. Cyrus Eaton's Ungava Iron Ores reached a decision at year-end to spend some $200 million to develop its property for production of 5 million tons of pellets yearly, mainly for European markets.

The decision of United States Steel to develop its Quebec Cartier project in Ungava marked another important milestone in Canada's ore picture. Work is underway for building a 193 mile railroad, a power plant and a concentrator to produce 8 million tons of high grade pellets annually, at a cost of $300 million. Lowphos Ore Ltd., near Capreol, whose 600,000 ton concentrator is ready to produce, deferred commencement of production early last year because of the slack ore demand.

The friction hoist room at Steep Rock Iron Mines Limited, Ontario.



Uranium

Canada moved up to second place, ahead of South Africa, in world uranium production during 1958, more than doubling the 1957 output of 12.9 million pounds to reach a record total of 28 million pounds of uranium oxide in 1958. This increase in productivity will continue through 1959 and reach its peak in 1960, which will be the first full year of continued capacity operations for all plants now operating or planned.

Canada's strong position in uranium potential is due to reserves presently estimated at some 375 million tons of ore, 95 per cent of which is in Ontario and the balance divided between Saskatchewan and the Northwest Territories. All of the planned 19 milling plants, with combined capacity of 43,000 tons daily, were operating prior to mid-1958, but some have yet to reach capacity production.

New Production

In the Beaverlodge field alterations to the Lorado custom plant delayed attainment of full capacity and efficiency until early 1959. In the Bancroft area of Ontario, Canadian Dyno Mines went into operation in May, and expect production at rated capacity of 1,000 tons daily by the end of 1958.

In the Elliott Lake area Milliken Lake Uranium Mines built its milling rate up to capacity of 1,000 tons daily by year end. Stanleigh Uranium Mining Corporation commenced production early in 1958 and attained a rate of more than 2,000 tons daily in the fall, with expectation of 2,600 tons a day by mid-1959. Stanrock Uranium which went into production early last year was up to a rate of 3,000 tons daily by year-end. Northspan has all its milling plants in operation and has been producing precipitates at contract rates for the last half of 1958, still obtaining some of its ore from Algom. Canmet attained capacity operation in October.

Nickel

Canada's production of nickel in

1958 totalled 278 million pounds, down 26% from the 376 million pounds produced in 1957 which was nearly three quarters of the Free World trade. The oversupply situation observed in 1957, was aggravated last year by a recession in industry, a sharp decline in defence requirements, particularly in jet engines, and a drastic curtailment of steel production.

Canada still accounts for about two-thirds of the Free World's output and expansion plans underway will ensure that this ratio will not be materially changed. Capacity in Canada in 1959 will total 392.5 million pounds, out of a Free World total of 549 million pounds. Of this, Inco's Sudbury plant's capacity is 310 millions, Falconbridge 55 million and Sherritt Gordon 27½ million pounds.

During 1958 Canadian production totalled 376.26 million pounds, due to Inco going on a 4-day week last summer and later to a strike at its Sudbury plants starting September 24 which lasted almost three months.

With defence applications for nickel decreasing, producers are co-operating with industry to encourage greater consumption, and to use nickel in as many new products as possible. The most promising prospects are in the fields of stainless steel, supersonic aircraft, turbines, machine tools, atomic energy and space vehicles.

Copper

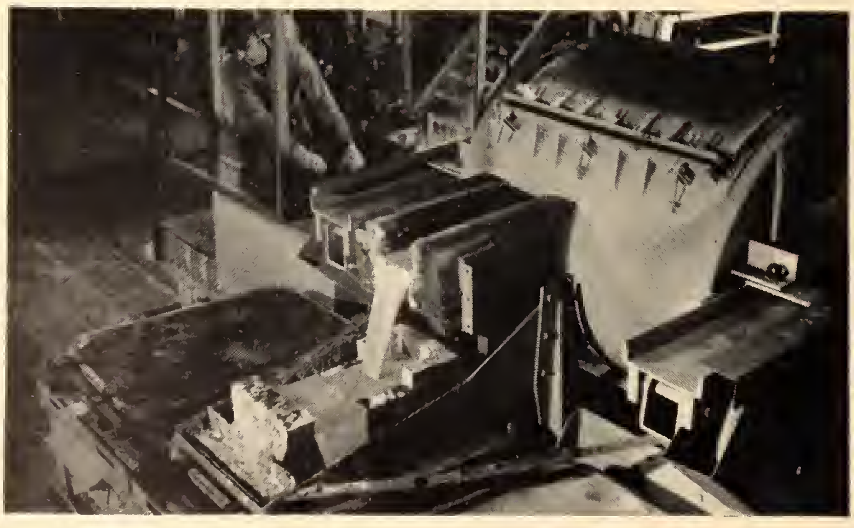
Canada in 1957 was the Free World's fourth largest producer of copper after the United States, Chile and Rhodesia. Record production of 353,293 tons was recorded in 1956. In 1957, production dropped slightly to 346,000 tons.

The free-world copper market held considerable encouragement at year-end. World production was down considerably last year, Northern Rhodesia mines with a combined output of 1,000 tons daily were strikebound for seven weeks. These, coupled with the Inco strike, took near 100,000 tons off the market. Copper prices have recovered from a low of 24 cents per pound in June to 29 cents at year end. Stocks of the metal have been reduced by a healthy margin. Consumption increased rapidly during the last four months of 1958 in the United States.

Geco Mines and Gaspé Copper mines were primarily responsible for the higher Canadian output last year. Geco attained production late in 1957, and average over 3,500 tons of ore daily. Gaspé Copper, which lost production of some 10,000 tons during 1957 due to a strike, produced steadily in 1958.

One new producer, Merrill Island Mining Corporation, started up its mill early in 1958 in the Chibougamau area. Copper-Rand Chibougamau Mines will go ahead with mill construction and will probably take ore also from Bouzan and Chibougamau-Jaculet. Hudson Bay Mining and Smelting closed early in 1958, but it is expected to re-open early in 1959. Other closures included Quebec Copper and Rainville Mines, whose grades were too low at 1958 price levels, and Goldstream for the same reason. Heath-Steele Mines in New Brunswick, Nickle Rim Mines and Min-Ore Mines also closed down.

New Inco Refining Process. Casting nickel sulphide anodes, one of the steps in International Nickel's new nickel refining process that marks a step forward in the Company's program to obtain maximum recovery from the ore it mines. The process is in commercial operation in a section of Inco's nickel refinery at Port Colborne, Ont.



In the Mattagami area of Quebec exploration has uncovered several new prospects, including the Watson Lake property of Mattagami Syndicate, sponsored by Noranda, McIntyre and Canadian Exploration. Craigmont mines and Bethleham Copper Corp. in British Columbia are investigating large low-grade deposits.

Lead

The outlook for lead is obscured by worldwide oversupply, lower demand and by U.S. import quotas based on 80% of average exports to the U.S. for years 1953/57 inclusive. On the other hand delayed cutbacks now being imposed are beginning to take effect. World mine and smelter production, which increased some 5 per cent in 1957, will show a reduction of 10/12 per cent for 1958. An attempt has been underway at a meeting in Geneva, attended by representatives of lead and zinc producing and consuming countries, to stabilize markets for these metals . . . Nineteen major producers from as many countries are financing research to expand present uses and develop new applications.

Canadian production for the first half of 1958 was only slightly off from 1957, but showed a substantial drop during the second half. Output for the full year amounted to 185,000 tons valued at $42.1 million or some 20 per cent below 1957.

Canadian exports of lead in ore and concentrates during the first half of 1958 were at about the same rate as in 1957, though refined exports were off some 7 per cent. However, the U.S. quota imposed on October first allows 12,000 tons more to enter the United States than was exported to that country in 1957. The largest reduction in Canada's imports of tetrethyl lead, due to the opening in 1957 of Ethyl Corporation of Canada's plant in Sarnia, helped to increase the balance of exports since that time.

At Consolidated Smelters' Pine Point Mines on the south shore of Great Slave Lake, large deposits of lead-bearing ores have been outlined, as well as in the Pelly and Highland river areas of the Yukon. In the Snow Lake area of Manitoba, Hudson Bay Mining is developing the Chisel Lake mine, where drilling has outlined nearly 4 million tons of ore. Heath-Steele Mines and Brunswick Mining in New Brunswick, and Sunshine Lardeau and Silver Standard in B.C., were closed down during 1958.

Zinc

Free World productions of Zinc in 1958 at 414 million tons was down only some 7% below the total for 1957, yet production still exceeded consumption by more than 20%. There were some cutbacks in Australia and the United States, which reduced their outputs 13% and 23% respectively below the 1957 figures. Canada and Mexico, the other two major producers both produced more than in 1957 during the first eight months, and for the full year their production was about the same as in 1957 or slightly higher. Between them, the four major producing nations mentioned above account for just short of one half of the free world's zinc production.

An intensive research program has been set up under auspices of the American Zinc Institute and process has already resulted in finding new applications for the metal, especially in the zinc alloy field. A new process has been perfected for smelting zinc in a blast furnace by Imperial Smelting Corporation.

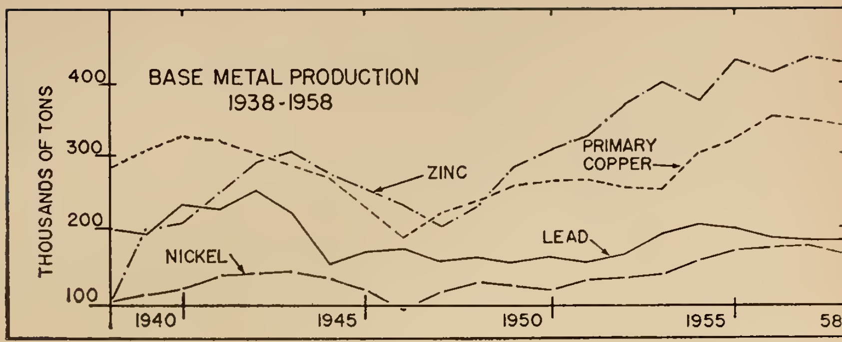
Gold

Free World production of gold in 1958 was close to the output of the previous year, when production was valued at $1.02 billion. South Africa maintained its leadership with an output of 17 million ounces, while Canada's output at 4.53 million ounces was slightly higher than in the previous year. Increase in Canadian gold production in 1958 was due principally to the high grade mines in the Red Lake area. During the year production at Norlartic mines was revived, while Bralorne, Campbell Red Lake, Cochenour-Williams and Barnat improved their outlook by developing new and higher-grade ore bodies. There was little prospecting done, and for the longer term the outlook for gold mining in Canada is clouded by the lack of new mines being developed.

Cobalt

World supplies of cobalt continue to accumulate and demand appears to be falling off. Little improvement can be expected until new uses are discovered, until the demand for high-temperature alloys increases, until U.S. stock become diminished, and business conditions improve. The U.S. is still stockpiling and lower-priced metals are replacing cobalt in certain standard uses, such as for permanent magnet alloys.

International Nickel, Falconbridge and Sherritt-Gordon are the big producers in Canada, with production in 1957 of 2.4 million lbs., 777,000 lbs., and 172,000 lbs. respectively. Total 1958 production was 2.52 million pounds. The Inco strike and decreasing U.S. demand considerably reduced the Canadian exports below the 1957 record.



Platinum

Though the demand for platinum up to two years ago greatly exceeded the supply, the position was reversed in 1957. The United States offers the main market, the oil industry being the largest consumer of platinoids, used as a catalyst for making high-octane gasoline. With the reduced oil production on the American continent the past two years the industry has cut back its purchases of platinum.

Most of Canada's production at 144,565 ounces comes from nickel producers, and with the long strike last fall at Inco production fell considerably below that of 1957. Canadian exports have fallen still further during the past two years.

Silver

World silver markets continued relatively stable in 1958, and prices are unlikely to drop below the current rate of 91 cents an ounce to consumers. Though business is recovering from the recession of the past two years, the effects included a drop in silver consumption for the arts and industry, though a 16 million ounce increase in 1957 for coinage largely compensated for the drop in arts and industry usage.

Canada's 1958 production was 31 million ounces compared with the 30 million ounces produced in 1957.

Consolidated Smelters, leading producer, with a 10.9 million ounce output in 1957, produced somewhat less in 1958. Torbrit Silver Mines in Northern B.C. had a slightly lower output. Hudson Bay Mining remained at about the figure of 1.5 million ounces the previous year. The combined output of Geco and Wilroy, new producers in 1958, just about compensated for the decreased production from "Smelters" and Inco.

Magnesium

Throughout 1958 there was an oversupply of magnesium, although the business upturn during the last quarter brought in new demand, bettering the outlook for 1959. World production may be below the record output. The U.S. produced 81,263 tons in 1957, with Russia in second place at 60,000 tons, while Canada produced 8,097 tons followed by Norway, Italy and France in that order. Canada's 1958 output amounted to 5,800 tons.

Canada uses only 12 per cent of her production, exporting the balance. A stiff tariff shuts off export to the United States. European demand has been steady and has improved in recent months, but the Japanese market has disappeared due to the collapse of the U.S. titanium market in connection with which magnesium was used.

Magnesium metal is finding new uses in many domestic and industrial products and in defence, notably for missiles and jet engines. The supply is unlimited, since in addition to many large deposits it can be extracted from salt water of the oceans. Canadian exports in 1957 were valued at $4.5 million. Last year the amount was substantially lower.

Lithium

With the supply of lithium still ahead of demand by a wide margin and with U.S. chemical processing capacity at double current production, lithium faces a difficult period over the next few years in establishing itself as a civilian commodity. Though most of the production is dependent on government purchase for defence purposes, such as rocketry and satellites, producers are concentrating efforts to build their future on civilian demand. In 1957, 30 million pounds out of the 42.2 million pounds produced went to the Atomic Energy Commission and other government agencies.

Canada's only producer is Quebec Lithium, which produces some 165 tons of lithia concentrate daily. The entire output is exported to the United States and in 1958 it totalled 3.94 million pounds valued at almost $2 million. Brazil, Southern Rhodesia and the Belgian Congo are also producing nations.

Barite

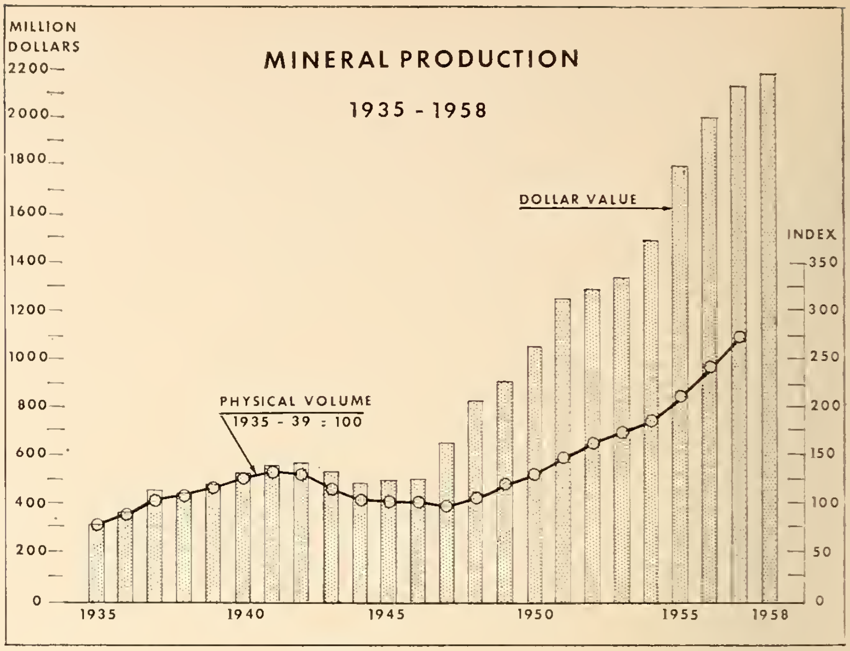
More than three-quarters of barite production is used to make "drilling mud", a weighting agent in drilling oil wells. The drop in exploratory well drilling in the United States and particularly in Canada, and the 20 per cent cutbacks in consumption last year created a problem for barite producers. Prices, however, have remained relatively steady. The United States is Canada's best customer and in 1957 took 77% of Canadian barite production.

Canadian barite production last year dropped to 180,000 tons, compared with 228,000 tons the previous year. Production for 1959 increased to 201,000 tons. There are three producers—Magnet Cove Barium Corp. in Nova Scotia, Mountain Minerals, and Giant Mascot Mines in British Columbia. Magnet Cove is the largest and produces some 90% of Canada's output.

Fluorspar

In spite of a drop in consumption and production in the U.S. the world's largest user of fluorspar, the world outlook improved in the latter half of 1958, except in Canada. No exports were made by Canada last year. U.S. stockpiles, which took all available Canadian exports in 1956 and 1957, were filled more than a year ago.

Canadian production in 1958 was valued at $1.55 million, considerably below that of 1957. Mexico, due to her low cost production, can sell competitively in Canada. About 10,000 tons were imported from that country in 1958, about 75 per cent of Canada's total fluorspar imports. There are three Canadian producers, Newfoundland Fluorspar Ltd., St. Lawrence Corporation of Newfoundland, Huntingdon Fluorspar Mines in Ontario.



Tungsten

Demand for tungsten has fallen sharply reflecting near termination of U.S. government supply contracts and a slower tempo of business. The use of tungsten has shifted gradually from high speed steel to tungsten carbides. Expansion for the latter is continuing. The opening of new fields, such as jet and rocket transportation, electronics and nuclear energy, however, give promise of a growing market for tungsten alloys.

Canadian production in 1958 was 691,000 lbs. of concentrate, compared with nearly 2 million lbs. in 1957. Canadian Exploration Ltd., Canada's sole producer, completed its contract with the general Services Administration of the U.S. last June

Table 1—Preliminary Estimate—Value of Mineral Production by Provinces ($ Millions) in 1958.

CATEGORY	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T. YUKON	CANADA TOTAL
Metals	62.98	—	0.93	176.41	636.33	26.55	93.97	9.61	108.93	36.00	1,142.14
Non-Metalics	1.71	9.42	0.94	101.81	20.94	1.97	4.39	2.30	14.03		158.13
Fuels	—	49.48	6.76	—	7.93	14.47	106.36	312.47	9.71	0.54	507.73
Structural Materials	4.05	5.10	8.41	92.58	133.96	13.15	8.99	23.41	24.47	—	314.15
Total 1958	68.75	64.00	17.05	370.80	799.17	56.15	213.72	338.79	157.14	36.54	2,122.15
Total 1957	82.68	68.06	23.12	406.06	748.82	63.46	173.46	410.21	178.93	35.51	2,190.32
Principal Minerals produced in order of importance	Iron ore Copper Zinc Lead Sand-Gravel Silver Fluorspar Cement	Coal Gypsum Salt Sand-Gravel Barite Stone	Coal Cement Stone Sand-Gravel Peat Moss Zinc	Asbestos Copper Iron ore Gold Cement Sand-Gravel Zinc Titanium	Uranium Nickel Gold Copper Sand-Gravel Cement Iron ore Salt	Petroleum Nickel Copper Cement Sand-Gravel	Petroleum Uranium Zinc Cement Potash Salt Gypsum	Petroleum Nat. Gas Coal Cement Sand-Gravel Sulphur Salt	Zinc Lead Silver Sand-Gravel Gold Asbestos Cement Coal Iron ore Nat. Gas Copper	Gold Uranium Silver Lead Zinc	

and its tungsten mining and milling operations at Salmo, B.C. were suspended. Exports were well below 1957. Imports of tungsten ores, on the other hand, were almost double those of 1957. Atlas Steels Ltd. of Welland, largest Canadian Consumer, uses some 80% of the total ferrotungsten and scheelite used in Canada.

INDUSTRIAL MINERALS AND FUELS

Potash

Culminating 10 years of research and development, first production of potash took place in Canada 15 miles west of Saskatoon, producing 168,000 tons in 1958. Potash Company of America reached the potash horizon at 3,335 ft. in July. The concentrating plant will handle 4,000 tons daily to produce 600,000 tons of muriate of potash per year. Another company, International Minerals and Chemicals Corp. (Canada) Ltd., has nearly half completed its shaft at a cost to date of $7 million, and will start production this spring at 400,000 annually.

Sulphur

Within two years Canada will become the world's second largest producer of sulphur and its products. Two new plants, Jefferson Lake Petrochemicals of Canada Ltd. in the Fort St. John area and B.A. Oil Co. at its recycling plant at Pincher Creek, Alberta, were in production during most of 1958. Two more plants for recovery of sulphur from sour natural gas will be in operation this year. Total output for 1958 amounted to 99,645 tons.

Lime

Demand for lime was at an all time high in 1958 as a result of requirements by the construction industry and uranium production. With three new plants completed or under construction, production at 1.6 million tons exceeded that of 1957 by 20 per cent.

Coal

Coal production at 11.4 million tons in 1958 was 12 per cent below that of 1957. This was largely due to reduced industrial production, the railway dieselocation; inroads of natural gas and to the shut-down at Sydney by Dominion Steel and Coal Co. last summer to reduce its stockpile. New Brunswick stockpiles had risen threefold to 100,000 tons.

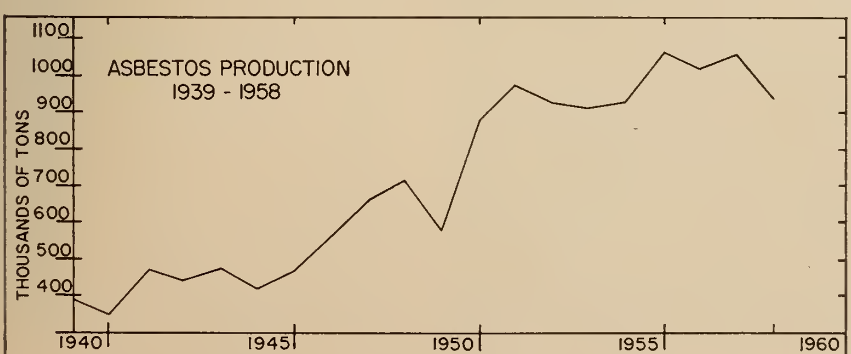
Asbestos

The Asbestos Mining industry in Canada is steadily moving forward to greater productive capacity, in the firm belief that there will be steady growth in world asbestos consumption over the next quarter century. In 1957 Canada produced just over half the world total of 2 million tons. Europe was the second largest producer by continents, at 575,000 tons including a probable 500,000 tons by Russia, followed by Africa, Asia, Australia and New Zealand, and South America in that order.

Productive capacity was up by some 15 per cent in Canada last year due to three new producers, Lake Asbestos of Quebec, National Asbestos Mines and Carey Canadian Mines, all in the Eastern Townships, and another 15 per cent increase in capacity is expected by 1960.

The recession last year caused a market decline in both Canadian production and exports. Output for the year totalled 942,000 tons compared with 1,061,419 tons in 1957. Exports, which account for some 90 per cent of production, declined more than 30% below the 1957 level.

While search for new deposits continues unabated, particularly in British Columbia and the Yukon, only potential new producer at present is Advocate Mines in Newfoundland. The Company has an agreement that may result in a 3,000 ton per day production by 1962.



Gypsum

Gypsum produced in Canada in 1957 totalled 4 million tons vs. 4.86 million tons in 1956. A year long strike at Canadian Gypsum Co. was settled in October.

Salt

Production of salt in 1958 amounted to 1.86 million tons, slightly higher than that of 1957.

PETROLEUM

Canada's crude oil production in 1958 dropped below that of the previous year for the first time, recording a total of 165 million barrels, a 10 per cent drop below the 182 million barrels produced in 1959. Gross value at $403.4 million was 9 per cent less than in 1957. Alberta, the province with the largest output of some 113 million barrels compared with 137.4 million barrels the previous year, showed the sharpest loss of 20 per cent. Saskatchewan, with an output of 45 million barrels, showed a gain of 21 per cent over the 1957 production of 36.86 million barrels. Manitoba production at 6 million barrels showed little change from the previous year, while production from British Columbia and the N.W. Territories at 1.5 million barrels also showed little change.

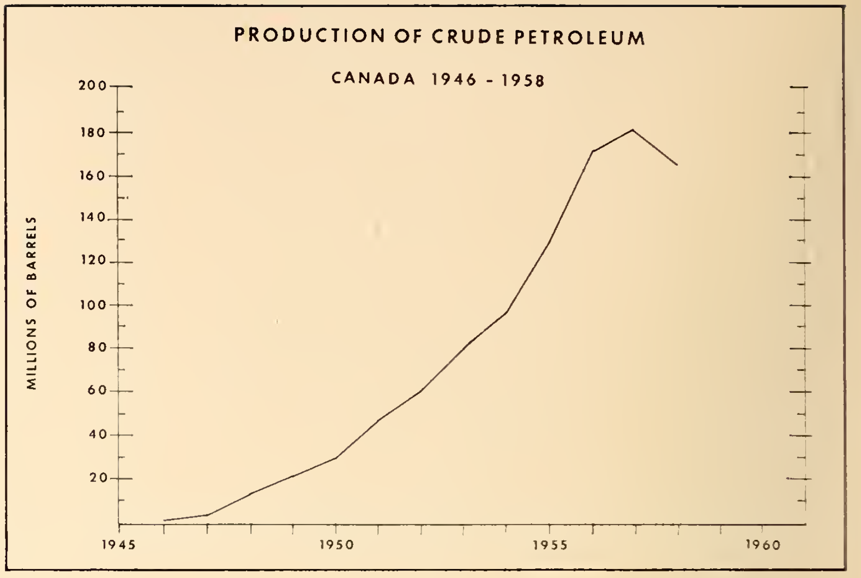
Domestic Market Steady — Export Down

Though the domestic market remained strong on all fronts, the overall decline was due to the drop in exports, mostly those to the west coast. Transmountain throughput for the year showed a total of only 12.6 million barrels against 40.4 million in 1957. Exports from Saskatchewan and Manitoba together added up to 18.6 million barrels against 14.2 million in 1957—a gain of 4.4 per cent.

The net loss of export markets was thus 23.4 million barrels, which left a modest increase of 3.9 million barrels in Canada's domestic consumption of Canadian crude. This was primarily due to diversion of crude runs to Ontario refineries, wherever possible, from the Montreal refineries which operate on imported crude, mostly from Venezuela. It was also due to a changeover to domestic crude by the Sun Oil refinery at Sarnia, which heretofore had been using imported mid-continent oil.

Drilling

Though total completions for the year were down to some 2,400 wells, 16 per cent below the previous year's total of 2,963, they were higher than in any year prior to 1955. The most noticeable difference to previous years was the reversal of trends in Alberta and Saskatchewan. Alberta completions, at 1,550, showed a 10 per cent gain over 1957 while Saskatchewan completions at 800 were 35 per cent below the previous year. Manitoba showed only 85 completions against 224 in 1957, while B.C. and North West Territories at 75 completions showed a drop of 18 per cent. Footage drilled of some 12.5 million feet was only about 9 per cent below the 13.8 million feet put down in 1957.



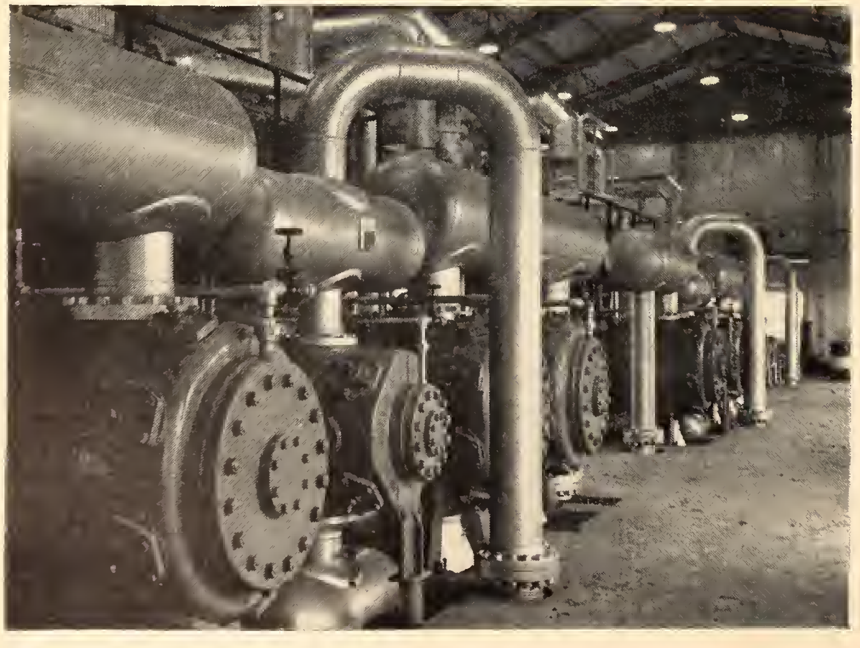
Exploration

Exploration activities were also curtailed. The year 1958 ended up with some 1,100 crew-months for both oil and gas exploration, 20 per cent below the 1,389 crew-month total of the previous year and the smallest aggregate of work since 1949. The trend marks the inevitable decline in the number of new prospective areas to be explored as the western sedimentary basin becomes more nearly saturated with geophysical records. The outstanding problem is now muskeg as wildcat activities move northward. Muskeg research is a dominant element in future exploration methods and policy. Vehical development depends heavily on the research program for leads as to types of equipment suitable for use in muskeg.

Crude Discoveries

Though 1958 was not an outstanding year for finding new oil pools of importance; quite a number of new finds were recorded which assisted in bringing reserves up to an estimated 4 billion barrels. Best discovery during the year was in the Slave Point area in Northern Alberta where six oil accumulations have already been found in an area of 12,000 square miles. The Swan Hills-Whitecourt-Red Earth-Kaybob, Virginia Hills-fields are all in this area. An active search program was being concentrated there during the winter of 1958-59.

Interior view showing huge 2000 h.p. gas compressors at the Steelman gas plant located 2 miles north west of Steelman, Sask.



Less Development Drilling

The steady trend towards wider spacing of wells, with minimum spacing of 80 acres in fields with good porosity and permeability has sharply cut the amount of drilling required to develop a given area. Likewise increased rig and crew efficiencies have reduced drilling time and hence the number of rigs needed.

Refining

Additions to crude refining capacity in 1958 totalled 61,000 b/d, divided between British Columbia, Ontario and Quebec. Cracking capacity additions totalled 27,800 b/d, divided between British Columbia, Quebec and Ontario, in that order. Capacity now includes 834,550 b/d for crude refining in all Canada and 363,715 b/d cracking capacity as shown in Table 1.

Though domestic crude runs to Canadian refineries were sustained due to substitution of domestic crude from Ontario refineries for imported crude from Montreal refineries total refining operations were down some 10 per cent compared with 1957. This was due to the general business and industrial recession which showed only modest improvement as the year came to a close. Total runs of crude in Canadian refineries amounted to some 230 million barrels, compared with 239 million in 1957.

Refineries under contract for completion in 1959 and 1960 total 440,000 b/d capacity for crude, asphalt and aviation gasoline, and 50 million c.f.d. capacity for gas processing. Ad-

ditions are divided by province as follows:
Alberta 33,800 b/d; Saskatchewan 3,000 b/d; Manitoba 6,700 b/d; Ontario 35,000 b/d; Quebec 24,000 b/d; Maritimes 38,000 b/d; and Alberta some 50 million c.f.d. gas processing capacity.

Moderate Improvement seen for 1959

Alberta producers started the new year with nominations at 383,715 b/d, vs. 365,860 b/d in December, featuring a reduction for Transmountain and an increase for Interprovincial. Observers predict the upward production trend in crude production will be resumed in 1959, gaining possibly 5 per cent over the 1958 daily average for an increase of some 25,000 b/d, or a total of some 171/173 million barrels for the year, regaining at least half of the lost volume last year. This assumes no increase in west coast shipments for export, but also assumes U.S. import quotas will have no adverse affects on the current volume going to northern states.

Refining operations, they forcast, will improve moderately to some 250 million barrels. Exploration will settle down at around 1,000 crew-months unless there is a material change in the market outlook. Drilling activity will decline only about 10 per cent below the 1958 level. With any increase in the oil market or further gas export the completion total could recover to 2,500 wells and footage to 13 million feet.

NATURAL GAS

Canada's natural gas industry in 1958 experienced the most exciting year in its short history. Vast developments in all its phases were seen, from exploration and development drilling and completion of gas-processing plants by producers in British Columbia, Alberta and Saskatchewan, to the arrival in late October of Alberta gas in the central provinces, replacing all imports, and extension of gas mains in many eastern municipalities.

Though not looked upon as an improvement for new discoveries, several important new finds were made. The most promising was the huge Berland River field in the foothills of Alberta, 160 miles northwest of Edmonton, with a 600 foot Devonian D3 payzone. The initial open-flow potential of the discovery well was 400 million cubic feet daily, the highest rate ever recorded in Western Canada. Another promising find of gas was at Panther River, 200 miles to the southeast of Berland at a depth of 9,000 feet.

Production up 40 Per Cent

Production of natural gas enjoyed a tremendous increase in 1958, to an estimated 400 billion cubic feet compared with the 1957 total of 286 billion. Principal factor in the big increase was full-year operation of Westcoast Transmission's main line to the British Columbia interior and Vancouver and the export market to Pacific States.

Adding the volumes of gas already contracted for between Trans Canada and its eleven major utility customers between Regina and Montreal, totalling some 263 million cubic feet per day, to Westcoast's current contracts of some 400 million, makes doubling 1958's total production within four or five years appear a distinct possibility, even assuming completion of no further export pipelines within that period. This means looping programs or complete new lines must be nearing completion by that time to double capacity for the next period of expansion.

Big Year for Pipeline Construction

The year 1958 was the third largest in Canadian pipelining history for natural gas. The bulk of it occurred in Eastern Canada, where a total of some 1,100 miles of mainline were laid most of it between Lakehead and Toronto. This was made up of some 1,000 miles of laterals and gathering lines and an estimated minimum of 1,200 miles of local distribution systems or a total of 3,340 miles. A detailed breakdown of pipeline locations and mileages is shown in the sections dealing with Construction. The oil men should be able to hold their industrial customers and sign up new ones, but it is the domestic consumption where the real fight will occur.

Three More Pipeline Systems Projected

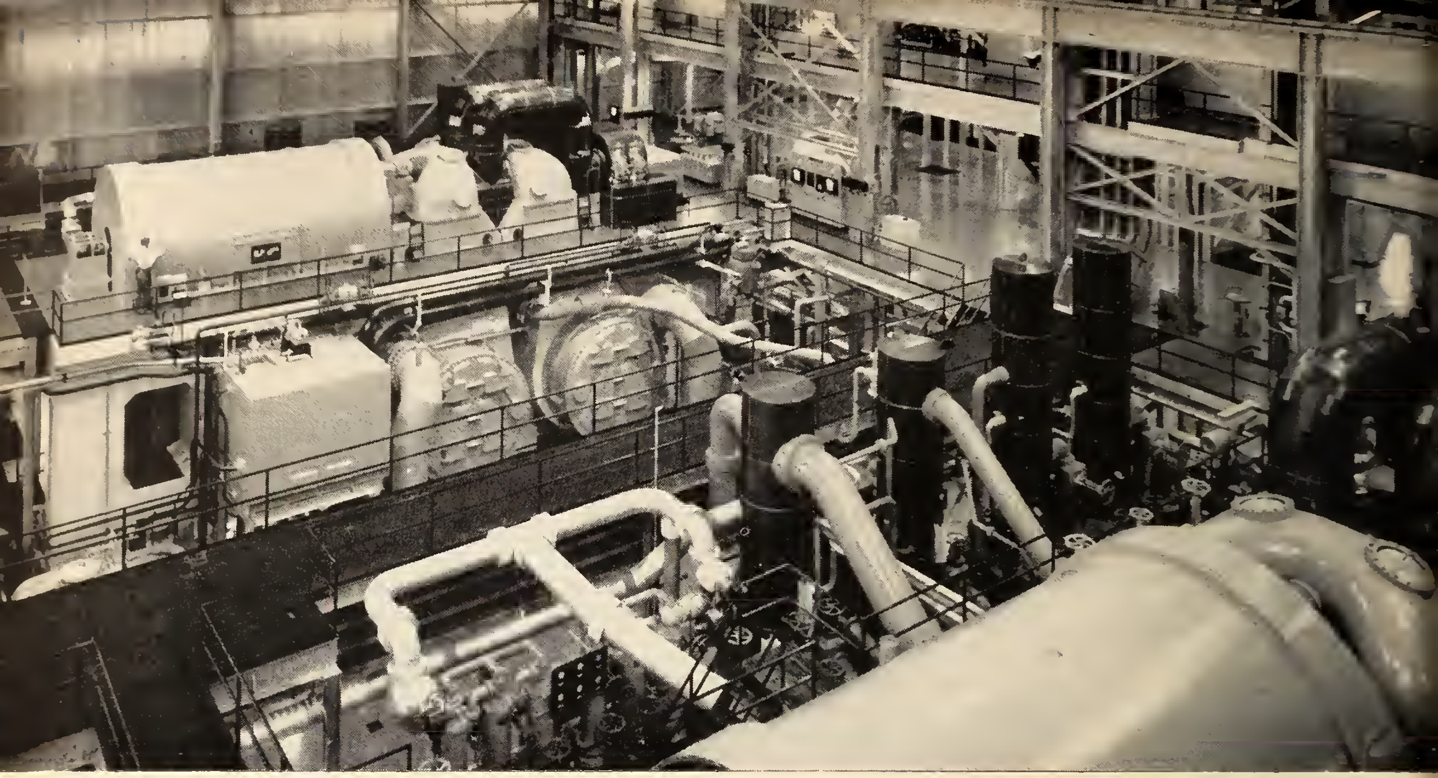
Two new pipeline projects are still awaiting approval to draw on the rapidly growing 'wet gas' reserves of southwestern Alberta for supplying the rich markets of California and the Pacific Northwest. One of these, sponsored by Westcoast Transmission, would provide a second Canadian link from southwest Alberta to feed through the Crows Nest Pass into the Pacific Northwest-El Paso system, already supplied by Westcoast from northern British Columbia fields.

Another alternative project, the Alberta and Southern, proposes a $300 million pipeline linking up a huge gathering system from Peace River to the U.S. Boundary, to be built by the Alberta Trunk Line to serve Pacific Gas and Electric territory in central California. The two large distributors of gas in Alberta, Northwestern Utilities and Canadian Western Natural Gas, are partners in the venture. Its approval could introduce more competition for the vast foothill gas reserves so far uncommitted to Trans Canada, with better wellhead prices and a higher load-factor market for producers.

Major gas discovery of 1958 was made at Berland River, Alberta, 160 miles northwest of Edmonton, where the jointly-held British American Oil well, probably the world's largest gas well, was brought in.

The Alberta Conservation Board in October advised these two pipeline organizations to re-submit their applications in January after reducing by 25 per cent the volumes they proposed to export, implying export permits would then be approved. No permits are yet received from the Board of Transport Commissioners nor from the F.P.C. at Washington.

Another multi-million dollar project is taking shape to market by-products separated from Alberta Natural Gas, to cost between $100 and $150 million. It would carry the products by pipeline in liquid form westward to Vancouver and eastward to the Canadian Lakehead ports or to Superior, Wisconsin.



POWER PRODUCTION AND DISTRIBUTION

AN ALL-TIME record was established in 1958 in the amount of new hydro-electric generating capacity brought into operation in any one year. A **net** total of 2,557,040 h.p. of new capacity was installed, after making allowance for the dismantling of 6,360 h.p. of existing capacity. The previous record was in 1954, when 1,785,450 h.p. of new capacity was completed.

Ontario Led, with Quebec Next

Largest single addition came from the first nine units of Ontario Hydro's Robert H. Saunders — St. Lawrence generating station, — the Canadian half of the International Powerhouse at Cornwall, producing 675,000 horsepower. Quebec's completion of the final three units of the Bersimis 1 development 300 miles northeast of Montreal added 450,000 horsepower.

Ontario provided the largest annual increase in hydro generating capacity for any one province, with 1,301,800 horsepower added during 1958, bringing that province's total installed capacity to 7,126,566 h.p. This, however, was lower than the Quebec total of installed capacity of 9,879,857 horsepower, which included the addition of 900,000 horsepower during the year.

The Department of Northern Affairs and National Resources forecasts addition of another two million horsepower in 1959 and some 2,600,000 in succeeding years. Of this Ontario expects to add 600,000 horsepower in 1959 and 360,000 more in succeeding years. Quebec's plans next year call for another 1,300,000 horsepower and more than 1,400,000 h.p. thereafter.

New thermal electric stations or extensions of present installations were proceeding in nine provinces as well as in the Yukon and Northwest Territories.

A Third of Canada's Power Resources Developed

The total installed capacity of water-power plants in Canada at year-end was listed at 22,470.040 horsepower, which represents 33 percent of total resources. In addition to these hydro-electric developments the building of new thermal-electric plants and extensions increased in 1958 in some provinces, notably British Columbia, Manitoba and New Brunswick, in that order. If this additional thermal capacity of some 662,000 h.p. is added, as well as some 3 million h.p. in service prior to 1958, the grand total of available power, both hydro and thermal is more than 26 million h.p. (Table I)

British Columbia

In British Columbia a total of

Calgary Power Ltd., Wabamun Power Plant. This view overlooks the generator of the first unit installed at the Wabamun steam plant. Beyond is the second 350 ton turbo generator which was commissioned late in 1958, giving the plant a total capacity of 144,000 kw.

189,700 h.p. of new hydro-electric capacity was installed during the year, while a further 35,000 h.p. was under construction for 1959 operation with another 475,000 h.p. in the planning or development stage.

The B.C. Power Commission completed the first stage of its Strathcona development on Vancouver Island near Upper Campbell Lake, where the initial installation of 42,000 h.p. was placed in operation in July. The 175 ft. earth fill dam here provides 800,000 acre ft. of storage. The Ash River development near Port Alberni was nearing completion and will be in operation by mid-February 1959.

The powerhouse, five miles below the storage dam at Elsie Lake, is below an 11 ft. diam. tunnel and wood-stave pipeline, and contains a 35,000 h.p. unit under a head of 700 ft.

The British Columbia Electric Co. Ltd. continued work on the final phase of its Bridge River development on the Mainland, for completion in 1960, when combined capacity of four plants will reach a total of 692,500 h.p. The final phase includes a second storage dam, to be called Mission Dam, a new powerhouse and a 16½ ft. diameter lined tunnel 12,700 ft. long. This dam, now under construction, will be 188 ft. in height, will raise the head at Bridge River No. 1 to 1,356 ft. and increase the capacity from 248,000 h.p. to 276,000 h.p. Another interesting feature is the deep grout curtain through the permeable material underlying the dam.

On Vancouver Island the company's 2,300 h.p. Goldstream plant, built early in the century, was dismantled.

The Aluminum Co. of Canada installed a seventh unit of 150,000 h.p. at its Kemano plant. An eighth unit comprising a turbine and generator of similar capacity had been delivered, but installation is being deferred for the present.

In the thermal-electric field, the B.C. Power Commission installed two 25,600 single cycle gas turbines at Chemainus, one late in 1957 and a second in January 1958; two regenerative cycle 24,000 h.p. gas turbine units were also being installed here for completion in January and February 1959. A 600 kw. diesel plant at Chetwynd near Dawson Creek will be in operation in January 1958; at Prince George seven diesel units with total capacity of 6,480 kw. were transferred to inactive plant and two more 3,000 kw. units are planned for operation in December 1959 and February 1960.

Elsewhere the following thermal installations were completed: 4,200 kw. in six diesel units at Quesnel and 1,800 kw. at Dawson Creek in three diesel units. In active prospect for early completion in 1959 or 1960 are 6,000 kw. in two diesel units at Dawson Creek, a 1,000 kw. Diesel unit at Smithers and a 100 kw. diesel unit at Alert Bay.

The British Columbia Electric Co. continued work on the Port Mann Gas Turbine plant near New Westminster, for operation early in 1959. The four 33,500 h.p. turbines will operate with natural gas as a preferred fuel or oil as a standby. The plant is designed to be remotely controlled from the load despatch office 15 miles away, from where 470,000 hp. of hydro power is already under remote control.

At Ioco on Burrard Inlet the company had commenced work on a steam plant designed for ultimate capacity of six units of 211,000 hp. each. The first unit is planned for operation in January 1961 and another in October, with the rest to follow as required by load growth.

Alberta

There were no new hydro-electric units installed in Alberta during 1958. Calgary Power Ltd. deferred work on extensions to its Spray and Rundle plants until 1959, where a 62,000 hp. unit and a 40,000 hp. unit will come into service respectively in 1960. Stream flow studies are under way on Brazeau River, a possible site for a future development.

In the thermal-electric field, Calgary Power doubled the capacity of its natural gas-steam station at Wabamun, by bringing into operation a second 66,000 kw. unit in October. Northland Utilities Ltd. is studying hydro sites on the Heart River near McLennan and on the Fridette River near Uranium City.

Northland Utilities Ltd. replaced a 500 kw. unit with a 3,000 kw. gas-diesel unit, while Canadian Utilities Ltd. placed in operation a 10,000 kw. gas turbine unit at their Sturgeon Plant. The city of Edmonton brought into service a new 10,000 kw. gas turbine unit at its municipal thermal-electric plant. The City of Lethbridge added a 10,000 kw. gas turbine unit to its municipal station, while the city of Medicine Hat built a 4,000 kva. substation.

Saskatchewan

An agreement was reached in July 1958 between the Federal government and the Province of Saskatchewan for joint construction of the South Saskatchewan River project. A hydro-electric installation of some 200,000 hp. will be included in the development.

The Churchill River Power Co. continued construction for addition of a 7th 19,000 hp. unit at Island Falls, expected to be in operation by July 1959. The Saskatchewan Power Corporation added a 66,000 kw. steam turbine to its Queen Elizabeth thermal station at Saskatoon. Capacity of the Kindersley station was increased by 20,000 kw. in two gas turbine units.

Manitoba

The Manitoba Hydro - Electric Board is building its Kelsey generating station on the Nelson River at Grand Rapid. Five or six units under a 50 ft. head are proposed, each of 42,000 hp. Two are scheduled for operation in July 1960 and three more during 1961. Installation of a 6th unit is being considered. The plant will supply power to the International Nickel mining development at Moak, Mystery and Thompson Lakes. Some 10 per cent of the powerhouse and 5 per cent of the main dams were completed by year-end. The diversion channel and sluiceway structures were nearing completion, and the 250,000 c.f.s. flow of the river was expected to be passing through the sluiceway by that time.

Thermal-electric projects underway in 1958 included completion of four steam turbine units each of 33,000 kw. at Brandon, while the Board's Selkirk generating station will place one 66,000 kw. in service in December 1959 and a second at mid-1960. The pumphouse structure on the Red River near Cook's Creek was completed for supplying cooling water to condensers. The Board's program is based on an expected increase in power demand through the winter of 1961-1962.

The Commission purchased four diesel generating units aggregating a capacity of 1,825 kw. and the distribution system at The Pas in December last. A new generating station was completed by year-end with two diesel units totalling 1,750 kw. and two of the units of the purchased equipment were being installed with them, bringing capacity to 3,150 kw.

The city of Winnipeg continued

with repair work at Pointe-du-Bois and Slave Falls power stations and completed two substations in the Winnipeg area. The Department of National Defence added one 1,136 kw. diesel unit at Churchill.

Ontario

Ontario's total of 1,301,800 hp. of new capacity installed during 1958 was the highest among the provinces. In addition, new capacity under construction is expected to add over 600,000 hp. during 1958 and some 360,000 hp. over succeeding years.

By year-end nine 75,000 hp. units were installed in the Ontario-Hydro's Robert A. Saunders - St. Lawrence Generating Station, with a capacity of 375,000 hp. The remaining seven units are scheduled for service by November 1959. The upstream earth fill cofferdam had been blasted on July 1st, 1958, and the headpond raised to within 4 ft. of normal operating level.

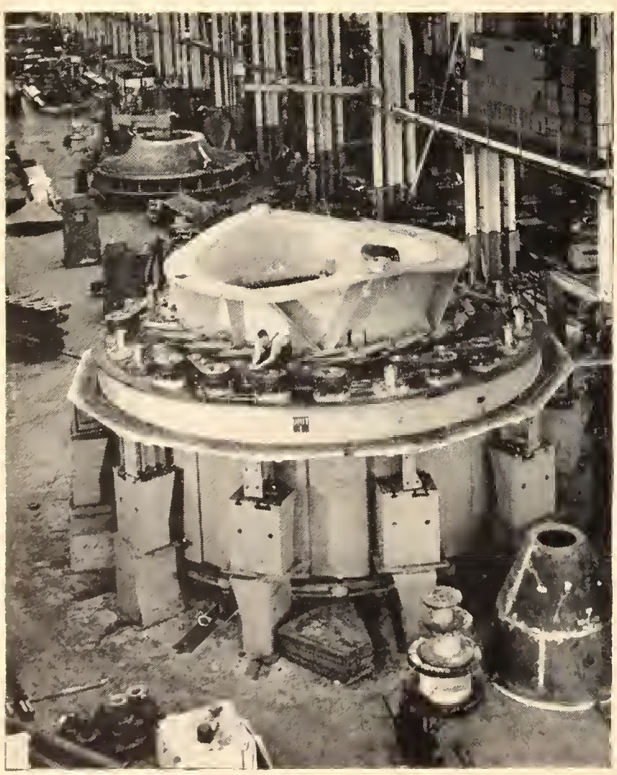
At the Sir Adam Beck - Niagara Generating Station the Commission completed development of the power resources on the Niagara River with the placing in service of the last three units of the pumping-generating station and of the last two additional units at the main station. Each of these units is rated at 105,000 h.p. Each of the six pumping-generating units has a capacity of 47,000 hp. at maximum discharge.

In February 1958 the first of three 27,000 hp. units was placed in service at the Whitedog Falls plant on the Winnipeg River. The other two units were placed in service in March and June respectively. A similar development at Caribou Falls on the English River with three 34,000 hp. units was placed in operation early in October.

Late in 1957 the Commission completed works for diverting water from Lake St. Joseph on the Upper Albany River system to Lake Seul in the English River System. This water provides additional power at Ear Falls, Manitou Falls and Caribou Falls on the English River, and the six plants on the Winnipeg River in Manitoba. The two provinces have an agreement for sharing the additional power produced in Manitoba.

One additional unit was also added during the year at Manitou Falls on the English River, and at Alexander and Cameron Falls on the Nipigon River. These additions have added some 62,500 hp. to the Commission's installed capacity.

Construction was also started during 1957 at Silver Falls on the Kaministiquia River, of a 60,000 hp. single unit generating station. By the end of 1958 a tunnel had been excavated and partly lined, and 30 per cent of the powerhouse structure was built. When placed in service next September it will be remotely controlled from the Port Arthur transformer station.



Shop erection of a 200 h.p. turbine for the Beauharnois Development of the Quebec Hydro-Electric Commission.

A new generating station with two 26,500 hp. units on a head of 93 ft. will be built at Red Rock Falls on the Mississagi River, for operation in 1961. By year-end first-stage cofferdams had been built and the headpond area partly cleared. Further upstream on the James Bay watershed another generating station was under way at Otter Rapids 23 miles from the Abitibi Canyon Plant, to be placed in service in 1962. The powerhouse, integral with the dam and sluice structures, will house four 60,000 hp. units. The Commission also plans to increase the output at Abitibi Canyon with a fifth 66,000 hp. unit.

During 1958 the Commission also undertook construction of two new thermal electric stations, the Lakeview Station west of Metropolitan Toronto and the Thunder Bay Station at Fort William. A third station is planned for the Hamilton area. Good progress was made on enlarging the Richard L. Hearn Generating Station to 1,200,000 kw., or three times its present size.

Studies were continued with Atomic Energy of Canada Ltd. and other interested agencies regarding development of a large-scale reactor for production of energy from nuclear resources. Plans for a 200,000 kw. nuclear station are being developed. Meantime construction was resumed at Des Joachims on the Ontario side of the Ottawa River. Work on this 20,000 kw. nuclear station had been temporarily suspended in 1957 to permit changes in design.

Apart from the activities of the Commission, the Great Lakes Power Co. placed in operation in October at Gartshore Falls on the Montreal River, a generating unit of 30,300 hp. capacity under a 115 ft. head. The company is also going ahead with its Cat Falls development on the Michicopoten River for initial operation in June 1959. This plant will have one 30,300 hp. unit under a 95 ft. head.

Quebec

In the Province of Quebec, installation of hydro-electric facilities totalling 900,000 hp. capacity was brought into operation. In addition, new capacity currently being built will add some 1,300,000 hp. during 1959 and more than a million hp. in later years.

Hydro-Quebec completed its 1,200,000 hp. Bersimis I project by adding units 6, 7 and 8. Each unit is rated at 150,000 hp. under a head of 785 ft. At Bersimis II, 23 miles downstream, where there will be five 171,000 hp. units under a head of 377 ft., three units are scheduled for operation late in 1959 and the remaining two late in 1960.

At Beauharnois the Commission continued construction of the third and final section of the powerhouse which will contain ten 73,700 hp. units with provision for a seventh. Initial operation with two units is expected in April, with a third to follow in June and a fourth in September. Completion is planned for 1961 with total capacity of 2,234,700 hp. The Commission also built a storage dam at Lac St. Anne on the Toulnoustouc River, a tributary of the Manicouagan. Studies were also underway regarding the development of the Lachine Rapids section of the St. Lawrence, and of the Carillon Rapids on the Ottawa River.

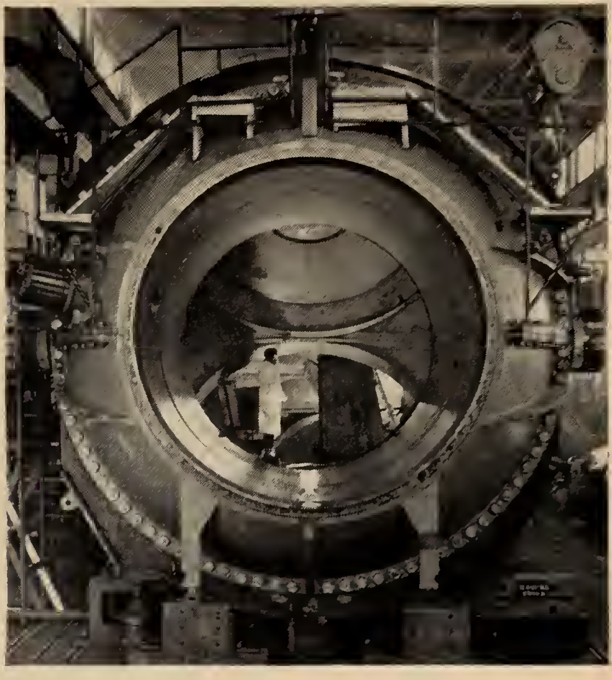
The Shawinigan Water and Power Co. brought into operation the first four 55,000 hp. units operating under 125 ft. head at its Rapide Beaumont plant on the St. Maurice River. Units 5 and 6 were placed in service in November-December. The Manicouagan Power Company completed its McCormick Dam No. 2, an extension to its plant at First Falls near Baie Comeau. The last two 60,000 hp. units were placed in service in March, bringing total plant capacity to 292,400 hp.

Quebec Cartier Mining Co. commenced a development on the Hart Jaune River last October, to supply power to its immense iron ore project in the Lac Jeannine area. A storage dam will impound 54 million cubic feet of water. Plans call for development of 66,000 hp. five miles downstream, in three units under 130 ft. head, with provision for two or three units at the storage dam at a later date.

The first of the five 200,000 hp. units at Aluminum Co. of Canada's Chûte des Passes project on the Peribonka, operating under a head of 625 ft. is expected to be in service by August 1959. The Company has indefinitely postponed a project to divert water from Manouane Lake into the Bonnard River, a tributary of the Peribonka.

The James MacLaren Co. Ltd., is building for completion in 1959 a 50,000 hp. plant on the Lièvre River at Dufferin Falls. The plant will have two 25,000 hp. units under a 62 ft. head.

Hollinger Hanna Limited is studying a possible 180,000 hp. development on the Aux Pekans River in the headwaters of the Moisie.



Foot bore straightflow valve for Bersimis No. 2 development under construction in the John Inglis plant.

The Gatineau Power Co. completed conversion of its equipment from 25 to 60 cycles at Paugan and Farmer's Rapids. Last remaining 25 cycle plant at Chelsea will be converted early in 1959.

Extensive repairs were completed on the Gouin Storage dam on the Upper St. Maurice and on the Allard Dam on the Upper St. Francis River.

Omitted from reported 1957 installations was a completion by Smelter Power Corporation, totally owned subsidiary of Nickel Mining and Smelting Corporation, which placed its 42,000 hp. hydro plant on the Chicoutimi River. (273 ft. head) in service in May, 1957.

New Brunswick

The New Brunswick Electric Power Commission placed in service in January 1958 the second of two 45,000 hp. units, in the thermal-electric field, at its Beechwood development. The NBEPC has currently under construction a 50,000 kw. steam plant at Saint John, expected to be completed next July. The Bathurst Power and Paper Co. completed addition of a 6,540 kw. unit to its steam plant at Bathurst, while the Fraser Company Ltd. added in mid-October a new 12,500 kw. unit at its Edmundston steam plant.

Nova Scotia

The Nova Scotia Power Commission purchased and dismantled two small plants on the Sissiboo River. In June construction was started on two new developments to replace them, 12,000 hp. in one unit at 125 ft. head at Weymouth Falls, and 8,000 hp. in one unit at 85 ft. head at Sissiboo Falls. Both will be in operation late in 1959. The Clearland plant on the Musquash River with its 330 hp. was dismantled. The Commission proposes two new plants on the Sissiboo at Riverdale and Wreck Cove with capacities of 8,000 hp. and 55,000 hp. respectively.

The Nova Scotia Light and Power Co. completed its new 73,000 hp. development in three units at Windsor Forks in December. Two more projects are in active prospect at Lequille and Alpina with 7,500 hp. and 6,500 hp. capacity respectively. During the year the Company was adding a 45,000 kw. unit to its Halifax steam plant for 1959 operation, while the Seaboard Power Co. was adding a 16,000 kw. unit to its plant at Sydney, with operation expected by September 1959.

Prince Edward Island

The Maritime Electric Co. is installing a 10,000 kw. unit at its Charlottetown plant for operation late in 1961.

Newfoundland

The Bowater Power Co. completed in March at Cornerbrook a 12,000 hp. development in two units under a 526 ft. head. United Towns Electric Co. added a 3,600 hp. unit to its hydro plant at Lookout Brook in November, while construction was commenced at Pitman's Pond on a 1,200 hp. plant in one unit under a 70 ft. head. Newfoundland Light and Power Co. Ltd. expected to complete in December 1958 a new 17,000 hp. development in two units under a 307 ft. head at Rattling Brook near Norris Arm. At its Manihek Rapids development in Labrador, Iron Ore Co. of Canada will add a new 19,000 hp. unit under 35 ft. head in 1960.

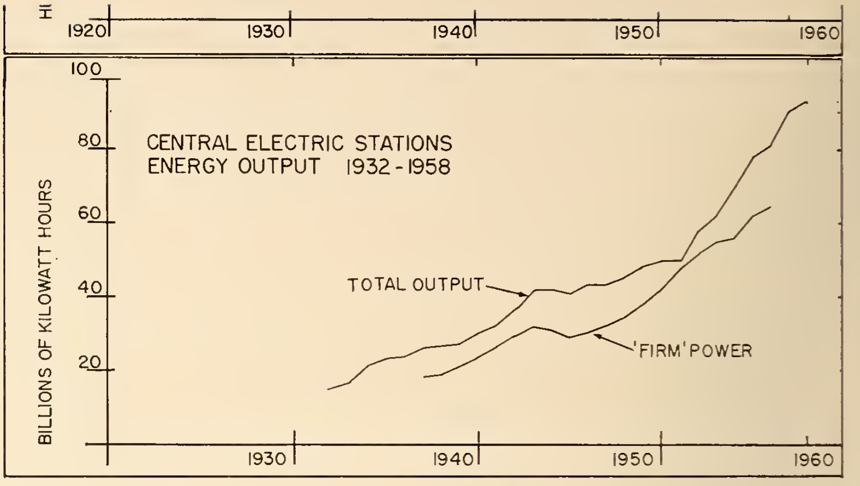
Yukon and Northwest Territories

At the Federal Government's Northern Canada Power Commission Whitehorse Rapids development on the Yukon River the first 7,500 hp. unit was placed in service in November, and a second similar unit at year-end. Provision is made for a third unit. On the Snare River in the N.W.T. the Commission plans a second development of 9,200 hp. in one unit, 8 miles downstrtam from the existing Snare River Plant.

Installation of thermal plants during the year included a 600 kw. unit at Fort Smith, (replacing 2-100 kw. units); a 150 kw. diesel unit in New Aklavik (now named 'Inuvik') to augment the two existing 375 kw. units as required. The Commission also commenced an extension to the existing Fort Simpson plant for addition of the 100 kw. diesel unit formerly at Fort Smith. The Yukon Hydro Electric Co., which is allied with Yukon Hydro Co. Ltd., installed a 150 kw. diesel plant at Haines Junction, Y.T.

Columbia Settlement Near

At the end of the year there were signs that the long controversy on Columbia River power may be approaching a settlement. Acting Prime Minister Howard Green announced early in December that "steps are to be taken at once to complete an agreement with the United States which will make possible the co-operative development of the River." This co-operation would be based on control of projects in Canada, he said.



This hinted that power from the Canadian stretch of the Columbia might have to be under a joint federal-provincial authority. It implied Canada will keep the regulation of flow in its own hands, possibly through a federal authority.

The Government also re-asserted agreement on flows and downstream benefits should be worked out by the International Joint Commission, rather than through diplomatic channels.

Expressing delight at Canada's readiness to negotiate, U.S. officials interpreted Mr. Green's statement as indicating Canada had abandoned the idea of diverting the Columbia into the Fraser watershed.

Other Developments

Ottawa is firmly opposed to any early development of power in the Peace River Canyon, as proposed by the Wenner-Gren group with Premier Bennett's backing, believing it will be most valuable 25 to 30 years from now. Federal authorities have never seriously feared that development of the Peace River might interfere with development of the Columbia. They believe it would not be feasible for private interests to dam the Peace Canyon unless they have an immediate market for most of the 4 million hp. potential. A market for so much power could not be found without export, and Ottawa has a veto over all power exports.

World Power Conference

Following the articles and reports on proceedings of the World Power Conference in September 1958 in Montreal, covered fully in the October 1958 issue of The Engineering Journal, there is little more to add regarding developments in nuclear power after so short a lapse of time. These developments were covered in articles commencing on pages 63, 75 and 85 of that issue.

TABLE I—Power Installations for 1958-1959-1960 and Planned for future years.

	Installed in 1958		Scheduled for 1959		Scheduled for 1960		Planned for 1960 or future years	
	Hydro hp.	Thermal kw.	Hydro hp.	Thermal kw.	Hydro hp.	Thermal kw.	Hydro hp.	Thermal k2.
British Columbia	192,000	228,000	35,000	145,600	475,000	340,000	(a)	340,000
Alberta	..	103,000	..	..	120,000		..	
Saskatchewan	..	86,000	19,000	..	..	..	200,000	
Manitoba	..	199,136	..	66,000	84,000		126,000	
Ontario	1,301,800	..	600,000	..	360,000	20,000	..	200,000
Quebec	900,000	..	1,300,000	..	1,400,000		(b)	
New Brunswick	45,000	190,040	45,000	18,875	..		..	
Nova Scotia	5,000	..	20,000	61,000	..		77,000	
Prince Edward Island	..	..	..	..				10,000
Newfoundland	32,600	20,000	..	..	19,000		(c)	
Yukon and Northwest Territories	15,000	1,550	..	100	9,200		(d)	
CANADA	2,563,400	827,126	2,219,000	289,575	2,449,200	360,000	403,000	550,000
Less dismantled	6,360							
NET TOTAL	2,557,040							

Footnotes—(a) Excluding Mica Dam and diversion of Columbia, and 4 million hp. on Peace River.
(b) Excluding Lachine Development.
(c) Excluding 4 million hp. at Grand Falls.
(d) Excluding 4 million hp. on Yukon and Nass Rivers.

PULP AND PAPER INDUSTRY

CANADA IS THE largest exporter of pulp and paper in the world. More than four-fifths of the total output moves abroad. Some 92 per cent of newsprint production is exported and 90 per cent of the pulp manufactured for sale also goes to foreign markets. With an annual volume of production valued at $1.4 billion, pulp and paper accounts for 7 per cent of the output of all Canadian industry. At current values the industry represents an investment of some $3 billion.

Production in 1958

Total wood pulp produced last year at 9.907 million tons declined almost 3 per cent from the 1957 level and by 5 per cent from the all-time high established in 1956. Canadian newsprint output for the year at 6.095 million tons was 5 per cent lower than in 1957. The productive capacity of the newsprint mills in 1958 was more than 7 per cent higher than in 1957. Thus by mid-year the operating ratio had dropped to the lowest level of postwar years.

Both in Canada and the United States, most of the recent additions to newsprint capacity have been completed. However, in 1959 operating ratios for the newsprint industry in Canada will continue to reflect the reserve capacity which was created in the last twelve months.

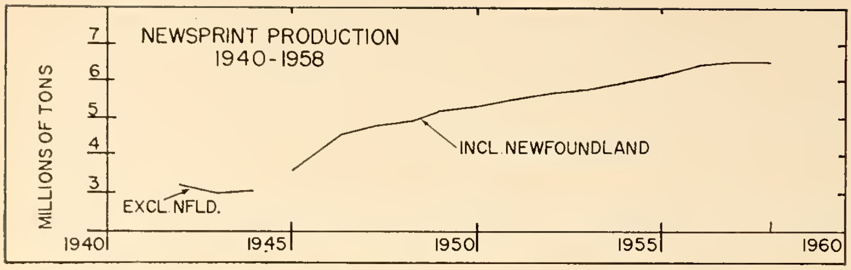
Paperboard production in 1958 surpassed the all-time record levels reached in 1956, and increased more than 6 per cent over 1957. Demand for fine paper was well maintained, with both production and consumption higher than in the previous year. Production of wrapping paper exceeded the record level established in 1956.

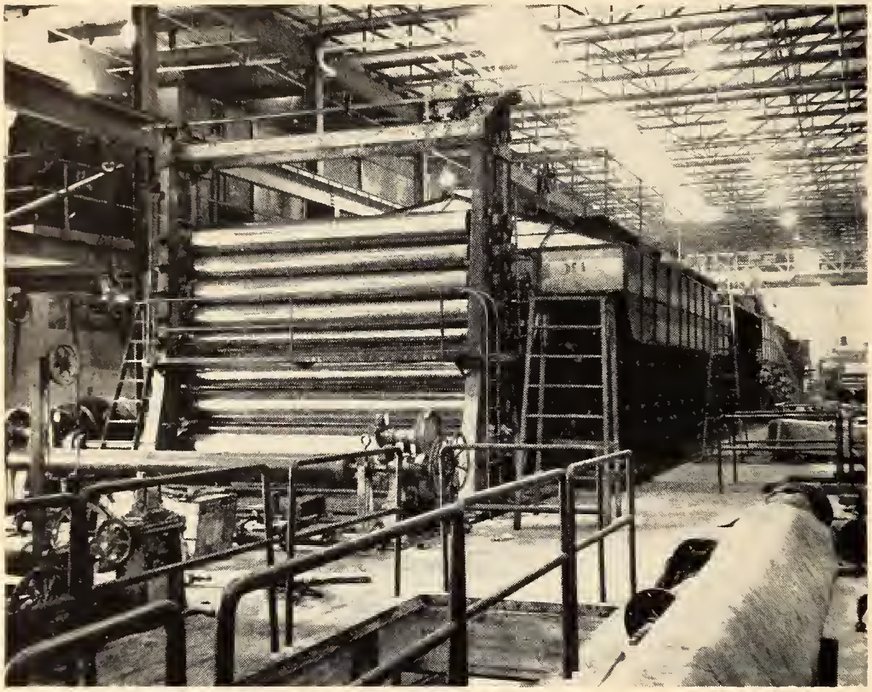
Technically, the industry continued to progress satisfactorily, with research programs underway both in the mills and in the woods. The budworm epidemic appears to have been halted, and productivity of the woods worker increased again. Today west of the Rockies it takes 1.3 man-days to cut and move a cord of wood to the mill, as compared with 1.8 man-days a decade ago—a 27 per cent reduction.

Industry Statistics

There are 80 pulp and paper companies, operating 130 mills in eight provinces. Almost a third of the United States' wood fibre requirements comes from Canada, which exports annually to the U.S. 1.8 million cords of pulpwood, 1.9 million tons of pulp and 5.2 million tons of newsprint, close to 2 million of which is eventually repulped for paperboard or other products. Of the total pulp and paper output 45 per cent comes from Quebec, 26 per cent from Ontario, 13 per cent from British Columbia and 16 per cent from five other pulp-producing provinces.

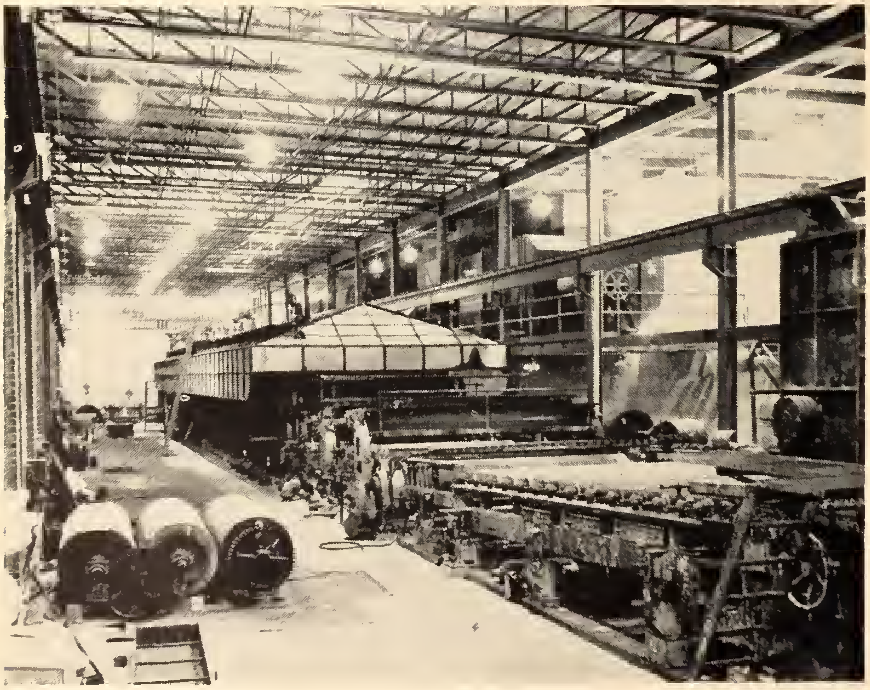
There are 26 companies making newsprint, which operate 146 newsprint machines in 42 mills. In addi-





Installation of No. 3 paper machine room. View from the dry end or calender stack. Donohue Brothers Ltd., Clermont, Que.

Installation of No. 3 paper machine room. View from the wet end or Fourdrinier end. Donohue Brothers Ltd., Clermont, Que.



tion to pulp and newsprint the mills have an annual output of 1.9 million tons of paperboard; book, writing, wrapping, tissue, cleaning, industrial and other papers; building papers and board, and hardboard and other pulp products. Next to newsprint, the paperboard plants are the largest producers, making 900,000 tons annually. Canada also produces more than 250,000 tons per year of fine papers from 15 mills.

Including 95,000 woods workers, pulp and paper creates employment for some 335,000 workers. Even excluding its seasonal workers totalling some 270,000 pulp and paper is one of the largest employers in the land.

Technical Sessions

Among technical subjects discussed at the annual C.P.P.A. meeting were factors affecting Fourdrinier wire life. In papermaking the soupy pulp flows on the moving wire mesh screen where the water drains away. Pulp fibres felt together into a wet sheet. With today's high speed of paper machines replacement of Fourdrinier wires has risen alarmingly. An industry-wide task force had been studying the problem.

Another session dealt with chemical pulp problems. Chemical pulp is produced by cooking wood chips in an acid or alkaline solution. Exports are valued at some $275 million annually. A paper was presented on advances in the design and operation

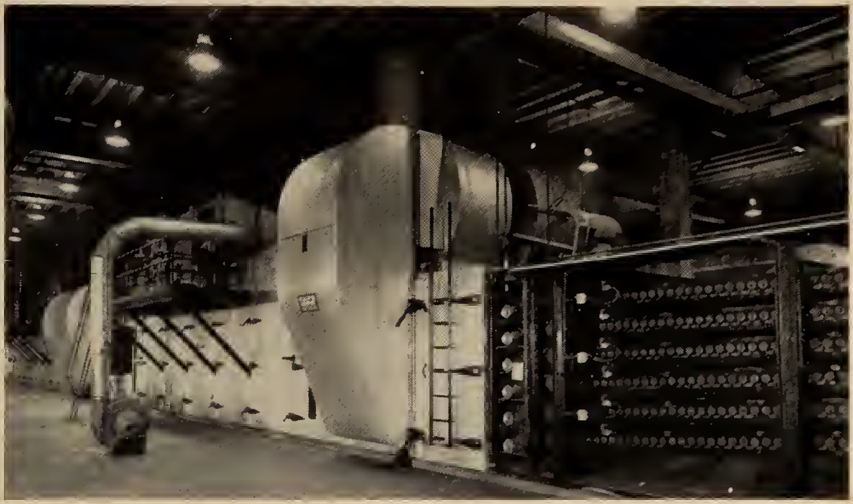
Towering 250 ft. above the wild woodlands of Northern Quebec is the largest differential surge tank of its kind in North America. This was erected for Price Brothers and Company Ltd., pulp and paper manufacturers.

of chlorine dioxide generators for bleaching the pulp. Another paper dealt with purity and bleachability of pulps.

Discussions on fine paper manufacture included a paper on research into factors that allow paper to curl, and another dealing with pitch-dispersal chemicals that permit production from resinous woods such as jackpine. Paperboard production problems were discussed, such as the large quantities of steam used in papermaking, alkaline pulping of poplar and a new technique for continuous rather than batch-pulping of northern hardwoods.

Another session dealt with handling and storing of raw materials, palletization, trials of a special pulpwood railway car, and a case history of an industrial truck driver's training program were subjects of addresses. A boxboard session discussed packaging, sizing, quality control and uniformity. A session on pulp blending discussed a magnetic stock proportioning control system, as well as stock flow and measurement through orifices. In a session on mechanical engineering, subjects included methods of getting more pulp from a given amount of wood, electrical engineering, and alkaline pulping of hardwoods.

A session on paper drying was devoted to infra-red radiation in papermaking; bark disposal, new processes of bark utilization, and use of bark to generate steam. Discussions related to static rectifiers, fundamental chemistry of wood, drying and ventilating and operating problems of paperboard production as well as testing and quality control.



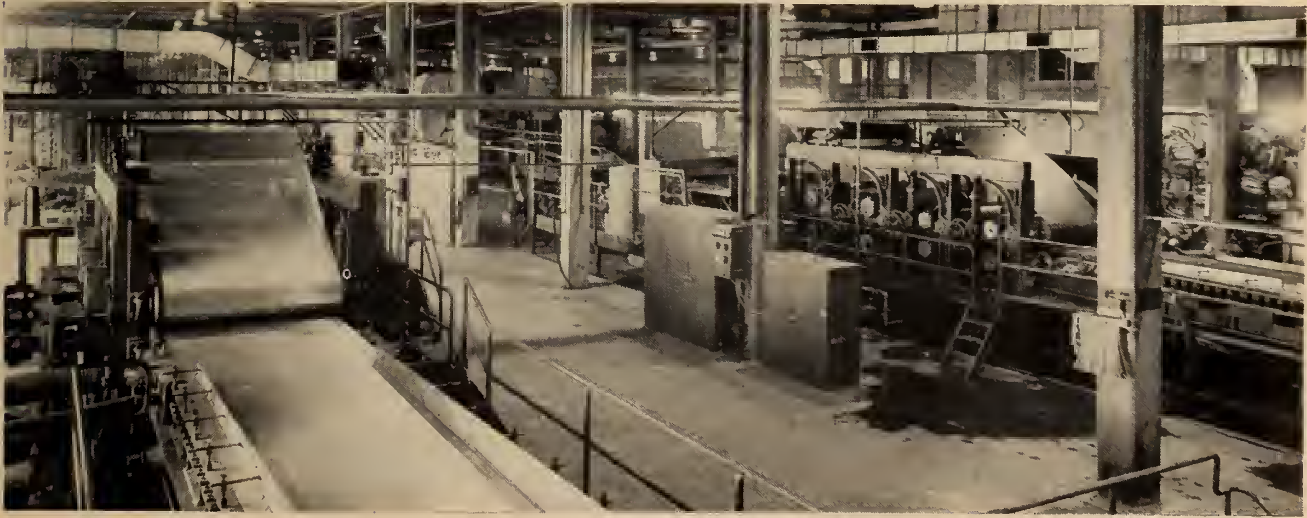
Infeed section Coe tunnel dryer for softboard at Prairie Fibreboard Limited, Saskatoon, Sask.

Table I—Canadian Pulp and Paper Production and Exports—1957-1958

Preliminary 1958 figures

	Production		Exports	
	1958	1957	1958	1957
Gross value of output	$1.4 billion	$1.4 billion	$1 billion	$1 billion
	Tons	Tons	Tons	Tons
Total wood pulp	9,906,712	10,176,707	2,213,701	2,232,185
Dissolving and Special Chemical	306,551	341,411	248,789	291,523
Bleached sulphite paper grades	553,775	583,300	349,191	384,736
Unbleached sulphite	1,558,383	1,754,162	209,424	297,036
Bleached sulphate	1,118,627	882,970	880,669	716,353
Unbleached sulphate	833,862	775,391	259,362	256,020
Other chemical	235,463	244,823	32,343	41,311
Groundwood	5,234,675	5,516,713	226,498	237,697
Newsprint	6,095,553	6,396,501	5,609,024	5,907,393
Containerboard	485,845	455,495	50,058	57,402
Boxboard	420,258	390,063	26,497	22,262
Total paperboard	906,103	846,008	76,555	79,664
Fine paper	254,068	252,086	15,873	16,270
Coated paper	30,960	29,450	1,227	1,202
Other printing paper	91,641	80,925	63,820	54,590
Special papers	128,367	124,800	3,785	5,218
Wrapping paper	287,930	269,177	28,720	18,836
Building papers and boards	320,000	272,000	15,000	23,300

View of hardboard and softboard forming machines at Prairie Fibreboard Ltd., Saskatoon.



RESEARCH AND SCIENCE

John R. Kohr

At the concert: "Ma, what's the book the conductor is reading?" "That's the score." "Oh? Who's ahead?"

SCIENCE IN CANADA has always been a concerted effort rather than a competitive sport; and this is still true in 1958-59, both internationally and internally. Internationally, we don't crave a place in the race into space at a quickening pace just to save face; and internally, we have become a nation where even distillers make exhortation toward moderation!

The score of science in Canada—and I make it a point not to say "Canadian Science"—is composed of thousands of research notes, conference proceedings, annual reports, technical journals, science lectures, and even television shows; the orchestration is provided by federal and provincial government laboratories, by independent research organizations, and, increasingly, by universities and by industry.

At the last count, in 1957, industry alone employed some 4,500 professionally trained scientists—the number had doubled in the short span of two years! — and some 3,500 technicians. Multiply these figures by some 40 hours a week for some 50 weeks a year . . . and you'll hear the wheels of progress hum . . . to the point where this symphony of science will begin to sound almost like the Flight of the Bumblebee. No wonder that the voice of the "vocal soloist", the lone inventor, is nowadays seldom heard in the land.

However, this marathon musical metaphor was not meant to end on a sour note but rather with the three "leitmotivs"; expansion and improvement of research facilities; focus on higher standards of education in the sciences; and, finally, increasing emphasis on supra-national aspects of science.

Postdoctorate Fellow from India, using vacuum apparatus to concentrate biological materials without having to apply heat. The commonly used heating method would decompose these "Thermolabile" substances. Work of this type is done in the fermentations and enzymology section, Division of Applied Biology, National Research Council, Ottawa.

Expansion and Improvement of Research Facilities

Increasing interest of industry in research-development is shown by investment in new or extended research facilities, which amounted to $12.8 million in 1957. This is more than 20% of the estimated value of all facilities used for research up to 1955. Indications are—from the size and number of industrial laboratories opened in 1958—that this rate of growth will be kept up for several years to come. This means, roughly speaking, that during the 'fifties, Canada will have experienced an industrial research expansion equivalent to that of the entire half of the century!

Government research laboratories are beginning to show a more—shall we say, conservative—rate of growth. This is not surprising if one considers that in Canada large and powerful research organizations in government departments dealing with natural resources had already existed long before industrial research in this country was able to get going. Long-range plans for veritable networks of government research laboratories, conceived shortly after World War II, have now been largely put into effect by the Department of Agriculture, Atomic Energy of Canada Limited, Defence Research Board, Mines and Technical Surveys, and the National Research Council of Canada.

Notable additions are: the new forest products laboratory of the Department of Northern Affairs and National Resources; the new testing laboratory of the Department of Public Works; the telecommunications laboratory of the Defence Research Board; a plant biochemistry annex to N.R.C.'s Prairie Regional Laboratory; and the Fire Research Laboratory of N.R.C.'s Division of Building Research.

The Fire Research Laboratory is unique in Canada. Almost half of its 550,000 cubic feet consists of a huge, 40 ft. high hall that houses two enormous furnaces, the one for research into fire resistance of walls, the other for fire resistance of floors. Cost of the laboratory, including equipment: a cool million dollars. Cheap, if one compares it with the 44 million dollars damage caused by 25,560 fires in 1958, in Ontario alone! Invaluable, if one considers the 450 persons injured and the 155 lives lost by fire in 1958, in Ontario alone! (Totals for Canada not yet available at time of writing.)

In the provincial field, an example of healthy growth was given by the Alberta Research Council which recently added to its facilities at the University of Alberta a large laboratory and pilot plant financed by the Alberta government to the tune of some $750,000.

Focus on Education in Science and Engineering

Talking of the University of Alberta reminds me that many other universities in Canada have launched a building program that reveals both the grasp of, and the reach for, benefits yet to be derived from higher education in *all* fields. In these plans, the biological, chemical, medical, physical, and engineering sciences are not being overlooked, to put it mildly. At Ottawa University, for instance, a million-dollar chemistry building has followed hard at the heels of a similar electrical engineering building, to be followed in turn by a million-dollar biology building. And on the brand-new campus of Carleton University, only a few miles away, the Henry Marshall Tory Building for Science and Engineering is nearing completion.

In the Maritimes, the biggest single step in expansion of facilities at St. Francis Xavier University recently culminated in the opening of a Chemistry and Physics building, erected at the approximate cost of—you've guessed it — a million dollars. (Could it be that the fascination exerted by this "round figure" has something to do with its pleasant plumpness?)

At Dalhousie University, erection of the Sir James Dunn Science building has been made possible through a gift by Lady Dunn of nearly two million dollars. (To explain this extra munificence, it may be worth while recalling for a moment that Dalhousie's present chancellor is, among other things, a professional engineer!)

Mount Allison and the University of New Brunswick have also made tremendous strides both in the enrolment of science and engineering students and in the corresponding provision of new facilities.

I have dealt here with the Maritimes at some length because I want to exemplify the gradual achieving of a healthy balance in these provinces between education in the natural sciences — where the low number of scholarship holders, for one thing, had indicated a significant lag behind the central and western provinces—and education in law and the humanities, in which the Maritimes had always enjoyed a Canada-wide reputation for their "export of brains".

But of all science building projects in Canada, by far the most magnificent, both in conception and in execution, is the new Ecole Polytechnique on the campus of the Université de Montréal. Built at a cost of nearly ten million dollars, it takes care of an enrolment of nearly a thousand students, making allowance even for

Not all pieces of equipment used in scientific research are as complex as this apparatus operated by a technician of N.R.C.'s Division of Applied Physics. ***Photo by Malak, Ottawa***

Teamwork is of increasing importance in most scientific developments. A valuable member of the team is this drafts-"man". ***Photo by Malak, Ottawa***

the enrolment being doubled within the next ten years. Could there be a finer symbol for the emergence of what I may call—if you'll pardon the bilingual "jeu de mots"—*le génie canadien!*

"Engineering is becoming ever more popular among the students in the French(-speaking) high schools and classical colleges (of Canada). The major industrial developments in Eastern Canada catch the eye and the mind of young French Canadians as they never did before. This, coupled with the normal increase in the school age population will soon result in a much greater participation of French Canada in national economic development. The new facilities of Ecole Polytechnique come at a good time to cater to the coming generation, which rightly sees the opportunities where they lie." (*The Engineering Journal,* January 1958, p. 89, in the first of a series of articles on Engineering Faculties in Canada.)

Preparing samples for testing of the physical properties of ice, in the snow and ice laboratory of the Division of Building Research.

Emphasis on buildings, and their cost, is of course merely a macroscopic and grossly materialistic measuring stick: a laboratory, to a team of scientists, means no more and no less than what an auditorium means to an orchestra; for, basically, buildings are merely a shell, to make a good performance resound in all its glory. Scientific apparatus—just like musical instruments—often involve major expenses, too: think of the computing centre at the University of Toronto, the nuclear reactor at McMaster University, the wind tunnel at the University of British Columbia; the financing alone, of these modern monumental "teaching aids" often involves separate contributions from various government and industrial sources.

Skilled hands remain one of the most valuable assets of any scientist. Photo shows grain fertilization experiment of the Department of Agriculture Research Laboratory, Winnipeg.

With some industrial corporations assuming an ever increasing share and constantly growing interest in higher education, it is gratifying to note that the golden age of the individual benefactor is far from being a thing of the past; not perhaps as flamboyantly enthusiastic as some seventy-five years ago, when Louis Agassiz founded the first outdoor laboratory, for which John Anderson—a tobacco merchant in New York—donated an island (complete with a solid fifty thousand dollars for operating expenses), while a Mr. Charles G. Galloupe contributed a yacht, and François de Pourtalès took care of building a harbour, to say nothing of Quincy Shaw who gave Agassiz a hundred thousand solid dollars "to be used for whatever seemed best". Still, McGill University recently was left a whole mountain, Mont St. Hilaire, with no strings attached. And another industrialist has converted his summer estate into a haven for tired, but far from retired, leaders of Canada's academic world, so that they would find time for some undisturbed fish . . . pardon me, philosophizing.

Supra-National Aspects of Science in Canada

The most significant, and perhaps the most satisfying, symbol of advances of science in Canada is its increasing international recognition. Here are some variations on the theme.

The International Geophysical Year, officially concluded on 31 December 1958, was undoubtedly the most valiant effort at international scientific collaboration ever to be made; in all fairness it must be admitted, however, that some parts of this far-reaching program assumed undertones of nationalistic competition; the Canadian I.G.Y. program became thus doubly remarkable: not only for the extent and diversity of its operations but also for its "down-to-earth" detachment from any motive that was not rigorously scientific. Even the removal of Ripple Rock—an eminently practical engineering project — was made to serve I.G.Y. scientists for explorations in geodetic theory.

A large-scale Postdoctorate Fellowship scheme, now in its twelfth year of operation, has been expanded so that it now welcomes to Canada some of the world's most brilliant young scientists, to work not only at the National Research Council but also at various other Government laboratories and even at universities.

Canadian scientists are being asked in ever increasing number to serve on missions for UNESCO; to participate in international expeditions (last year, for instance, to study aborigines in faraway Central Australia); and to help with the Colombo Plan, both as experts abroad and as mentors for Colombo Plan Fellows whose training requirements may range from learning how to build and run a nuclear reactor to studying the latest techniques of food and drug inspection.

Similarly, excellent liaison between Canada's Technical Information Service and its counterparts abroad was pointed up last summer when, for the first time, the European Productivity Agency seconded one of their bright young men to T.I.S. for a six-month study of its operation all across Canada.

On the other hand, Canadians continue to learn new and unusual approaches to scientific and technical problems from visiting experts: a striking example is the work done by a Swiss specialist during the past two winters on avalanche control in the Canadian Rockies, under the joint auspices of Canadian railways and N.R.C.'s Division of Building Research.

Some Canadian developments, such as the cobalt teletherapy unit, are being exported to many countries; the advances Canada is making in photogrammetric research have lead to substantial contracts between various underdeveloped countries and Canadian aerial surveying firms.

The two "Atoms For Peace" conferences may be cited as typical examples of large-scale meetings outside Canada, where Canada was able to contribute both her scientific contingent and by her popular exhibits. Speaking of exhibits, Canada's photo display at the "International Exposition on the Teaching of Sciences" held this winter at the Sorbonne, Paris, was so well received that Canada's Department of External Affairs has been asked to make it available in other European cities.

Canada has become a favourite "host country" for World Congresses, such as entomology, genetics, biometrics, and the World Power Conference. The largest scientific gathering ever to be held in Canada will take place when the Ninth International Botanical Congress will meet, 19-29 August 1959, in Montreal.

Montreal, Ottawa, and Toronto are among the cities now frequently chosen for annual meetings of scientific societies with headquarters outside Canada; e.g., the Institute of Radio Engineers and the Society of Chemical Industry. Eminent Canadian scientists have achieved the signal distinction of serving as presidents of international scientific organizations — although their nationality had, of course, little to do with the fact that they were chosen; they simply were considered best suited to hold the position.

Some scientists in Canada have also started to play a leading role in such supra-national endeavours as the proposed redefinition of the International Metre in terms of wavelengths rather than material standards. Moreover, in an agreement among Commonwealth nations and the United States a single value for the standard inch will become effective as of 1 July 1959: instead of the U.S. inch of 2.540005 centimetres or the British inch of 2.539996 centimetres, the inch adopted in Canada in 1951, measuring an "even" 2.54 centimetres will be accepted; again, the Canadian inch will be accepted not because it's Canadian but simply because it's easier to handle.

To the superficial observer, this may sound like straining at a gnat; but, contrary to popular opinion, this is precisely how progress is being made in the natural sciences; and yet, although "Science is Measurement", the progress of science itself is, fortunately, beyond all material measure . . . in Canada . . . as well as in the rest of the world.

Summer student—releasing weather balloon for the Department of Transport in one of Canada's Arctic outposts.

ST. LAWRENCE SEAWAY AND POWER DEVELOPMENT

THE OFFICIAL opening of the St. Lawrence Seaway marks the realization of a project conceived more than a century ago. As early as 1825 the Hon. Robert Young of Montreal began agitation for a deep waterway and seven years later his views received support in a widely publicized article "The Concise View on Inland Navigation". The professional engineer enters the story in the person of Thomas Coltrin Keefer, M.E.I.C. first president of the Canadian Society of Civil Engineers (1887) later the Engineering Institute of Canada. Thomas Keefer planned and supervised scores of waterway projects mostly for the improvement of traffic conditions on the Canadian rivers.

Looking downstream at the remains of Toussaints Island in the foreground. Ships which will bypass Iroquois Dam in the centre distance will be raised through Iroquois Lock and pass through what was formerly Toussaints Island. In this photograph the island has been excavated, flooded and the rim dyke is being removed by dredges.

In a series of books and in scores of pamphlets, articles and addresses around the middle of the century, Keefer put forth his views on the use of Canada's waterways. The St. Lawrence was to him a broad passage into the heart of a virgin continent whose commerce sooner or later must take to the seas. His remedy for falls, rapids, portages and other natural obstacles on the St. Lawrence system was to cut more and more canals so that ships of all nations navigating without interruption could pick up cargoes on every cove on the Great Lakes.

The Welland Canal

In 1913 the Canadian Government undertook a project which would ultimately form part of the completed seaway. The new Welland Ship canal fourth and largest of a series of four canals built in Canada to connect Lakes Erie and Ontario, was commenced in that year. Work was suspended in the fall of 1916 but was resumed after World War I and was completed in 1932 at a capital cost of $130 million. The last eight miles of channel are now being deepened to 27 feet. But a newer Welland canal costing some $75-100 million will be needed within 10 years. If the Seaway is to carry its full potential and pay for itself in 50 years, it is expected that tolls will enable Canada to build this duplicate soon enough to allow full development of traffic.

It was Mr. R. A. C. Henry, M.E.I.C., then chief engineer of Beauharnois Light Heat and Power Company who made the imaginative and far sighted proposal that the difficulties of power development in the Soulange section should be overcome by the construction of a canal between Lake St. Francis and Lake St. Louis to take the full flow of the St. Lawrence.

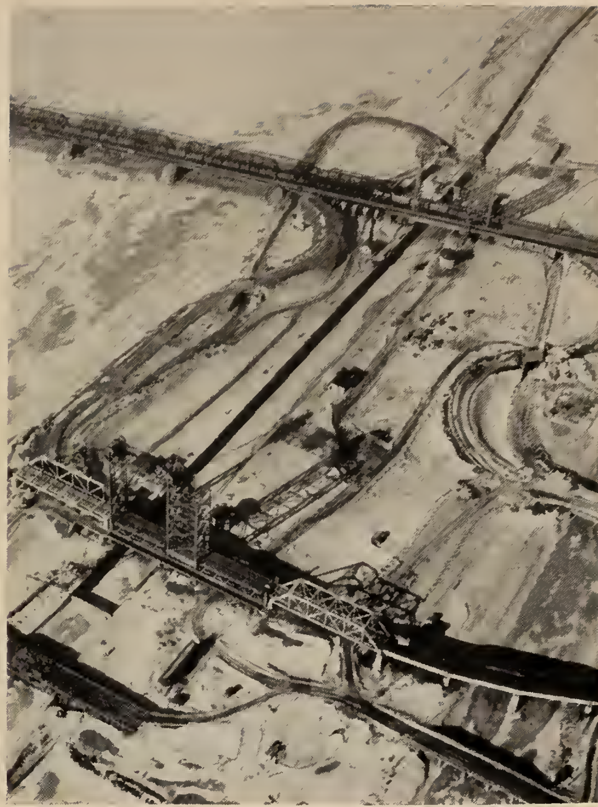
Beauharnois

The Beauharnois development, now owned and operated by Hydro Quebec, is one of the largest plants in Canada with one million three hundred and fifty thousand horsepower at present in store. When completed it will produce over 2,000,000 horsepower. Located in the Soulange section it was commenced in 1929 with the proviso that the power canal would later be improved and deepened and widened to the dimensions necessary for use as a navigation channel for the Seaway. The power canal is 16 miles long and is now being dredged to a 27 ft. depth throughout. Two locks have been installed by Canada's Seaway Authority.

Plans for the construction of the seaway proper, however, involved agreement in detail between Canada and the United States, and it was not until 1954 that the men and machines on each side of the border could actually begin their huge task.

Opening Ceremony

The ceremony last September at the powerhouse on the International Boundary was a tribute to the perfect co-ordination that has marked the four-year construction period of the St. Lawrence Seaway and Power Project. Premier Leslie Frost of Ontario and Governor Averill Harriman of New York State jointly pressed a switch to start eight generators delivering power on a commercial basis on September 5th, the exact date set four years previously for first delivery of power and partial opening of navigation through the new locks. The opening of the complete seaway on schedule will be the crowning achievement of this co-ordination between the Joint Commission, the Board of Control, the Joint Board of Engineers, the four Authorities and the many contractors and suppliers.



New approach to an old bridge: work began in 1958 on the construction of a new, alternate approach to the Victoria Bridge. This will provide an uninterrupted flow of road and rail traffic once the St. Lambert Locks of the St. Lawrence Seaway are in operation.

Raising a Bridge

The smooth operation of the intensive four-year program was marked by many impressive engineering accomplishments. Outstanding among these was the raising of the southern half of the 2½ mile Jacques Cartier highway bridge over the St. Lawrence at Montreal harbour to provide adequate overhead clearance for seaway vessels. The roadway profile was changed by jacking the spans and building up the bridge piers on which they rested to increase the clearance by 50 ft.

A further 33 ft. was gained by replacing one of the original deck-truss spans with a new through-truss span built on falsework on one side and slid laterally into place, pushing the old span on to falsework on the other side. Translation of the trans-channel span took place on October 20, 1957, closing the bridge to traffic for less than five hours on a Sunday morning. Jacking of the bridge was completed on July 2, 1958. The designer of the original bridge, the late Dr. P. L. Pratley, M.E.I.C., also designed this modification which fully preserves its artistic and practical value.

New Locks

Canada has built five of the seven new locks on the seaway between Montreal and Prescott that replaced 21 on the old system. The smooth working of the gate machinery in the new locks is another notable achievement. It takes only six minutes and causes a minimum of water disturbance to fill or empty a lock 80 ft. wide with a usable length of 768 ft., providing a lift of 6 ft. This is half the time taken in the Welland Canal locks built some 25 years ago.

The two American locks were opened to navigation for ships of 14 ft. draft early in July, and by the close of navigation a total of 5289 vessels had passed through these locks and through the Iroquois Lock on the Canadian side. By year-end work on the remaining four Canadian locks, St. Lambert, St. Catherine, and the Upper and Lower Beauharnois locks was completed,

Rolling lift bridges for the St. Lawrence Seaway Authority at Cote St. Catherine and Iroquois.

with the exception of machinery installation and testing of the lock gates, expected to be ready for the opening of navigation in 1959.

Rail Bridges

Early in October 1958 a 212 ft. 1,500 ton rail-highway lift span, assembled a mile east of the upstream entrance to the Beauharnois canal, was loaded on two scows and towed on three tugs to the site of the Valleyfield railway bridge crossing the canal. After one existing span had been removed and stored on pile supports the new lift span was raised by pumping out the scows and let down to exact position on the bridge piers. Later another 212 ft. span was towed 8 miles down the canal and installed on the N.Y.C.-St. Louis rail bridge.

International Powerhouse

Works of the power project also have been brought into effect with a notable smoothness of transition. One example of this has been the shortening of the customary dry-out period on the Canadian generators in the International Powerhouse, permitting the first two to be placed "on-line" within one week following the raising of water in the headpond.

The flooding sequence of June 30-July 5, 1958 was carried out with remarkably little dislocation of river traffic. At 4 a.m. on June 30, 1958 shipping was cut off between Cornwall and Prescott, Ont. on existing 14-ft. draught canals. At midnight stoplogs were placed in the closure structure after the last downbound vessel had cleared. At 4 a.m. July 1, gates of the Iroquois dam were opened to pass 310,000 cubic feet of water per second, then at 6 a.m. the tunnel ports of Long Sault dam were progressively closed.

At 8 a.m. on July 1 cofferdam A-1 above the Long Sault Rapids between Sheek and Barnhart Islands was placed with some 35 tons of explosive, releasing a 30 ft. wave which slowly inundated 30,000 acres of land creating an international lake 35 miles long and 5 miles wide at its widest point. At 9 a.m. the cofferdam at Ogden Island near Waddington, N.Y. was bridged.

With filling of the pool completed July 4, power production was commenced with two units on the Canadian side while navigation was resumed on July 4. By the end of that month seven units were producing power—three on the Canadian side and four on the U.S. side. At year-end eighteen units were in operation, nine in each half of the powerhouse.

INSTRUMENTATION IN INDUSTRY

POWER FIELD

IN THE PRODUCTION and distribution of electricity, instrumentation is an inherent part of the business, and some of the most exacting instrumentation systems in operation have been developed for, and are in use by, the electric power companies. The variety of types of instruments runs the gamut from simple indicating and recording instruments to precise electronic and hydraulic devices governing the speed of generators with amazing accuracy and complex switching devices which isolate a fault on a transmission line in a wide flung distribution system and, in less time than it takes an electric light to extinguish itself, transfer entire areas to alternate sources in the power grid.

A very large proportion of the fundamental equipment in many of the companies reporting consists of automatic, remote and supervisory control systems. One company operates ten hydro plants from a central control room operated by one man, and has a steam plant operating with a centralized system which allows the control and operation of two 66 MW units utilizing the services of one attendant per shift.

Reason for Instrument Installations

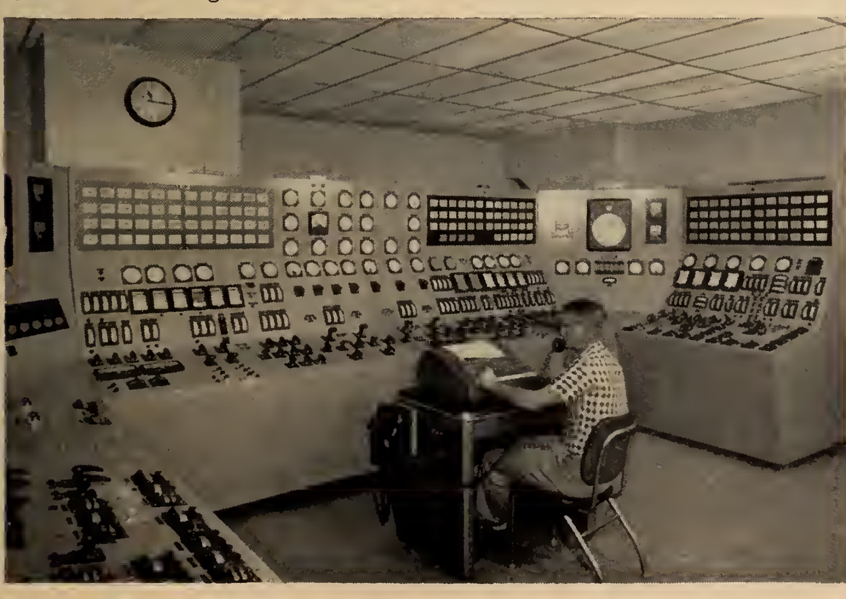
While it is generally true that a large amount of instrumentation is required in the production and distribution of electric power, it is interesting to note that the most important reason given by respondents for advanced instrument installation was to reduce the labour force. By using remote control relay systems, and automatic switching and protection equipment, they have been able to give a higher order of reliability in service with a shrinking labour force. Comments indicated that this trend will continue, probably at an accelerated pace, as labour becomes more expensive, and as reliability of electronic control devices improves.

With increased use of remote control, there is a general trend towards more recording instruments to give an accurate record of performance preceding, during and after troubles and faults occur. Other major reasons for investment in further instrumentation were for purposes of central supervision, for regulation of operating variables and for telemetering.

Uses of Instruments

Generally speaking, in the electric power industry, instruments are used to measure, regulate, protect, provide supervision and to provide records for analysis. Measurement is incorporated in the many metering instruments, and involves measurement of current, voltage, power, phase, speed, frequency, etc. Regulating instruments include both mechanical and electronic instruments, and include very sensitive systems such as those used to control turbine speed at modern hydro generating stations. The standard power frequency is taken so much for granted that many people lose sight of the fact that half the nation is timed by electric clocks which rely on extremely close control of generator speeds at power stations for their very high order of accuracy. Supervisory use of instruments includes those applications in which operating parameters are relayed to a central supervision point for control, and analysis of records obtained by use of continuously recording instruments enables engineers and technicians to do a better job of interpreting faults and equipment breakdowns, as well as providing continuous records of peak loads, miscellaneous faults, etc.

Calgary Power Ltd., Wabamun Power Plant. The nerve centre of the plant is the control room. All main equipment is controlled from here, including the equipment for automatically controlling the heat cycle of the steam generator. Instruments on the *console* are grouped for maximum clarity and convenience for the operator. The right half of the control panel shown in the photo regulates operation of the recently added 66,000 kilowatt unit. Section to the left commands the performance of the original installation.



Who Determines Instrument Requirements?

In the overwhelming majority of companies responding, the power companies' employees themselves determine the company's instrument requirements. Forty percent of the respondents indicated they also use consultants to specify their instrument while in isolated cases this work was performed by the staffs of affiliated companies, or by the engineering staffs of instrument manufacturers. In every case, the actual specification and recommendations for types of instruments to be purchased was done by the company's engineering department.

Who Buys the Instruments?

It was apparent from answers received that this question depends very largely on the internal organization of the companies involved. There appears to be a trend in some companies to appoint men with a technical background to their purchasing department, and then make them responsible for actually selecting the supplier who can produce to the specification supplied by the engineering department at the most favorable price. In the vast majority of cases, however (83%) the engineering department itself specified the actual brand of equipment, and the purchasing department acted in a passive role in bringing the equipment into the plant.

Servicing

Ninety-two percent of the companies responding to the questionnaire serviced their instruments themselves, and some reported fairly extensive instrument shops equipped to do a wide range of instrument repairs. Some of the companies maintaining their own instrument shops also purchased repair service as required, and this seemed to be more common where electronic control equipment with sensitive, and sometimes elaborate, test installations are required. One medium sized company with a great deal of modern control instrumentation does not operate an instrument shop, and buys all of its instrument service requirements as needed.

Preventative Maintenance

Respondents were split evenly on this question—half of them used an organized system of preventative maintenance, and the other half made repairs as failures occurred. The two largest companies reporting used a system of preventative maintenance, but there was no clear-cut pattern with regard to size of company in the remaining group—some of them did and some did not.

Remarks contained in answers to the questionnaire indicated that this is a field in which considerable research and investigation is required. Many companies who did not operate a system of preventative maintenance indicated that they had never attempted to isolate the cost elements involved in such an operation. There seemed to be a general fear that such systems grow by Parkinson's Law and become prohibitively expensive, whereas in actual fact the details of any such program are extremely flexible, and must be tailored to the individual needs of companies concerned. One company scheduled a yearly preventative maintenance check of all instruments associated with each generator in a multi-generator power house, and records over the years had shown this to be good economics. They fitted their program into natural breaks in generator service, and were able to make use of instrument technicians who would probably have been used with less than one hundred percent efficiency otherwise. They pointed out that their preventative maintenance program tended to equalize the workload in the instrument shop, and to lessen the incidence of all-out emergencies.

Spare Parts Practices

More than fifty percent of the respondents maintain a stock of spare parts built up through their own operating experience. Nearly forty percent stock the spare parts recommended by the equipment manufacturers. Some of these thought the practice somewhat expensive, and deplored the tendency by some instrument companies to "pad" the lists of recommended spares to bolster their sales and profit. They feel that good spares lists, conscientiously recommended by instrument manufacturers as a result of their own statistical experience, were a real asset to users of instruments, especially where new types of instruments are involved. They felt that instrument manufacturers interested in the long term picture could do an excellent service by providing "essential" lists of recommended spare parts.

Only a limited number of companies kept spare supplies of complete replacement units. This tied in with the preference for plug-in units. Apparently such units are not popular with the power companies, where many of the installations are permanent in nature, and where versatility is not so important as in manufacturing industries. A few did indicate a preference for the advantages of plug-in units where faults are concerned, especially with electronic instruments where faults may occur in cycles, and where repair time is difficult to estimate. A few spare plug-in units, especially where there is standardization of common elements, makes for a high degree of reliability of service in these cases, and there was some indication of a trend in this direction.

Instrument Specifications

The overwhelming majority of companies reporting preferred to use standard commercial lines for their instrument requirements. A few indicated that they usually have their more complicated control instruments built to their own specifications, and a few others preferred to modify standard instruments, with the engineering usually done in their own engineering department, and the modification usually done in their own instrument shops.

As would be expected in the field of electrical power supply and distribution, almost all of the companies own their instruments outright. A few companies reported rental of a small percentage of their requirements.—mostly computers and other costly equipment which are not used on a full-time basis.

Statistics on Instrument Usage

Capital investment in instrumentation was not given by about half of those responding, but the majority of the remainder reported investments in the range $100,000.00 - $500,000.00. One firm reported investment in instrumentation as between $5,000.00 and $25,000.00, and five reported instrument investment in excess of $500,000.00. Statistics on annual maintenance costs was also not well reported, but several indicated their annual expenditure to be in the order of $8,000.00 - $10,000.00 and one firm indicated an annual maintenance expenditure of $100,000.00.

Thirty-five percent of those replying reported an investment in instruments of over $200,000.00 during the past five years, and a large number reported investment of from $5,000.00-$50,000.00 over the same period of time. Recovery time for instrument investments was long, as might be expected in this industry. The majority of those reporting did not expect to recover instrument investments in less than 9 years, and many indicated much longer recovery times.

INTERNATIONAL NEWS

AUSTRALIA

SNOWY MOUNTAIN PROJECT. Progress is reported by the Institution of Engineers, Australia.

In the case of three contracts, assigned in late 1958, remarkable progress on the actual work of the contract has been achieved during the first six months.

Tooma Contract: This contract provides for the construction of the Tooma Dam and Tooma-Tumut Tunnel together with four small dams to divert water from secondary streams into the tunnel. The contractor, Thiess Bros. has opened up the Deep Creek Adit from which the tunnel will be driven in both directions. As at December 31, 1958, excavation of the adit was complete and advances of 3,100 and 2,100 ft. had been made upstream and downstream respectively. A drift from the tunnel for the raising of the Deep Creek intake shaft had been completed, and 300 ft. of excavation of a construction drift for the Tumut heading of the tunnel.

Tooma Dam will be of zoned earth and rock-fill construction, 230 ft. in height with a maximum base width of 1,200 ft. Excavation of the diversion tunnel for the dam is well advanced with 1,300 ft. out of a total length of 1,500 ft. completed. Excavation of the abutments and cut-off trenches of the dam site are well advanced.

T.2 Contract: This contract was awarded to the Joint Venture of Kaiser, Perini, Morrison, Raymond. It is for the construction of T.2 Diversion Dam, T.2 Power Station and the associated headrace and tailrace tunnels.

An extensive construction camp and housing area is being set up by the Contractor at the junction of the Tumut Tiver and O'Hares Creek some 5 miles downstream of the power station site. The direct road connecting the power station and the tailrace portal is also under construction.

The access tunnel to the power station site has been excavated for a distance of 2,000 ft. out of a total length of 3,600 ft. from the portal towards the machine hall.

A construction adit, 500 ft. in length, to provide access to the downstream end of the headrace tunnel and the surge tank has been completed, and excavation of the three miles long headrace tunnel has advanced 400 ft.

At the downstream end of the tailrace tunnel, open cut excavation is in progress and work has commenced on the tunnel portal.

Tantangara Contract: This contract provides for the construction of a concrete gravity dam 150 ft. in height together with the ten mile long Murrumbidgee-Eucumbene Tunnel. It was awarded to Utah Aust. Ltd., and Brown and Root Sudamericana Ltd.

The contractor is driving the tunnel from two faces at opposite ends and, at the end of December, the Murrumbidgee heading had advanced 3,300 ft. and the Providence heading 3,400 ft. Weekly advances of between 300 and 350 ft. are currently being achieved at each face. Excavation of the control shaft at the intake end of the tunnel adjoining Tantangara Dam has been completed.

At the dam site, stripping of the dam foundations is well advanced, grout hole drilling is in progress, and grouting of foundations has commenced.

Construction of the cofferdam for the river diversion channel was completed and the river diverted on the 20th November.

Aggregate and concrete batch plant is under construction and stripping of the quarry site from which coarse aggregate will be obtained is in progress.

Stripping of the stilling basin is also in progress.

UNITED NATIONS

SOLAR, WIND AND GEOTHERMIC ENERGY development is reported in a United Nations study on new energy sources.

The report (Doc. E/3218), prepared at the request of the UN Economic and Social Council, was to be considered by the Council's session, Mexico City on April 7.

The progress achieved, says the study, is the result of efforts by government agencies, manufacturing firms, individual inventors, universities and other organizations in various parts of the world.

Besides detailing technical and other developments in use of energy from the sun, the wind and the earth, the report puts forward a suggested agenda for a future international conference on new sources of energy.

In a summary of recent developments, the report says that direct conversion of solar energy to electricity by means of solar batteries and by thermo-electric converters is rapidly being advanced. Work also continues, though at a slower rate, on use of solar energy in steam-raising, air conditioning, refrigeration and water distillation. Less progress appears to have been made in developing solar heat storage, solar engines and use of solar furnaces for industrial production.

A significant feature of recent developments has been the increasing attention given to new materials, such as plastics, suited for use in solar equipment.

In the field of wind power, the past two years have been a period of "consolidation and of transition from experimentation to applied research and commercial use." In underdeveloped countries, wind power surveys have led, in a few cases, to the installation of the first modern wind power plants.

The linking of large wind-power plants to local or country wide grid systems is being explored, most of the work on this being done in Europe, it is noted.

As regards geothermic power (natural steam and hot water) the report notes that production of electricity from this source—limited two years ago to Italy—is being started in other countries. The greater interest in geothermic power is also reflected in the search for and discovery of new geothermic fields.

INDIA

WATER UTILIZATION. The chairman of the Central Water & Power Commission, Government of India, has recently published a paper on master plans for integrated water utilization (*J. Inst. Eng. (India)*, v.38, n.7, pt. 1, 1958). India has a geographical area of 806 million acres, of which land utilization statistics are available for only 719 million acres. In 1955 316 million acres were under cultivation, but only 18% of this area had irrigation facilities; about 40% of a further 87 million acres now classified as 'barren' is cultivable with irrigation.

There are great contrasts between flood and drought in the country, since annual rainfall varies from 5 in. to over 100 in., according to region. (Cherrapunji in Assam gets some 500 in. of rain a year.) On the one hand floods may destroy rich agricultural areas, on the other, nearly 30% of the land has a rainfall of less than 30 in. a year. At the same time the growth of population, and hence the need for more crops, is exceptionally great. From 362 million in 1951, it is estimated that the population by 1975 will be 492 million. Studies and surveys are proceeding towards the ultimate development of the necessary irrigation and water-control projects.

Hydro-Electric Power — The true potential of India's water resources for the production of electric power has to be related to the other aspects of flood control and irrigation schemes, and much survey work on individual sites is involved. However, current studies by the Central Water & Power Commission indicate an economic hydro potential of about 40 million kw. at 60% load factor. In addition there are large resources just beyond the northern boundaries of India, of which the most spectacular is on the Brahmaputra River, just inside Tibet, with a head of about 7500 ft. This could give 30 million kw. at 60% load factor for the mutual advantage of India and China.

Estimated maximum future demands for the whole of India are (in million kw.): 1960-61, 4.2; 1965-66, 7.2; 1970-71, 11.1.

Development Costs — It is estimated that the cost of irrigating 50 million acres of land, and generating and distributing 15 million kw. of power will total the equivalent of some $9.6 billion, exclusive of utilization costs. This is based on $64 for storing and distributing water to irrigate one acre, and $425 to generate and distribute 1-kw. of hydro power.

In recent years foreign technical and economic assistance has contributed to the overall planning for the water and hydro-electric developments. The largest aid has come from the United States, with considerable help also from the United Kingdom, Canada, West Germany, and others. Canada has made by far the largest contribution under the Colombo Plan. Assistance includes the provision of equipment and technical advisers, and of technical training facilities both in India and in the contributing countries.

WATERPROOFING MUD. About 300 million people in India live in villages where most of the houses have mud walls. These are badly damaged by rains during the monsoons. The Central Building Research Institute has developed methods of waterproofing and protecting the mud walls from erosion. One method uses a plaster of mud and 'cut-back' (bitumen diluted with kerosene and paraffin wax); another consists of painting the normal dry mud wall with a slurry of cement, hydrated lime, and fine sand mixed with soap solution. Cost is said to be within the reach of the ordinary villager.

BRITAIN. This large-screen projector can prevent "radar blindness". Six controllers are sitting at a large scale table plan of the airways round an airport as film is projected from above, by the Kelvin Hughes rapid processing projector, six seconds after the scene has been picked up by a radar set. Previously, each operator would have sat at his own cathode ray tube, and fed information to a central control system.

U.S.S.R.

SOVIET SPACE ROCKET. Abstract of an article by V. Chichakov, M.Sc., in the Soviet Press.

The Soviet rocket was intended to fly into outer space and to reach the second cosmic velocity (11.2 km — 6.959 miles — per second) or to exceed that velocity. The scientific apparatus of this huge flying laboratory was designed to study some specific features of outer space and chiefly that near the moon. These tasks were stated in the first announcement issued immediately after the rocket successfully got into the orbit set by calculation and the instruments.

The rocket headed for the moon, when the moon was in its "last quarter" phase. At that time the moon was almost perpendicular to the radius of the earth's orbit and ahead of the earth (in relation to the orbital movement of our planet).

The space projectile launched from the earth consecutively imparted to each of the subsequent stages of the rocket an ever increasing velocity, until, finally, the last stage acquired the velocity which until recently seemed fantastic and unattainable and which, as the calculations have shown, has enabled this body to move independently of the earth, breaking the fetters of the earth's gravitation. Together with the velocity the earth had at the moment of the rocket's launching, the imparted velocity became sufficient for the rocket to become a satellite of the sun which governs the movement of all the planets, comets, and meteoric and other bodies of our solar system. The rocket passed very close to the moon (at a distance of less than two diameters of the moon). It is this proximity which made it possible to receive the fullest data on the magnetic field of the moon and its radio activity. All the other scientific tasks of the space rocket were carried out independently of the rocket's nearness to the moon. These were general tasks of studying outer space. Now the rocket has completely established itself on its orbit around the Sun. That orbit is almost circular. It lies beyond the orbit of the earth and is about four times nearer to the earth than the earth's closest big planet, Venus.

It should be borne in mind that the information about the movement of the new planet will still be amplified. The impact of the planets of the solar system upon its movement will be studied. More accurate calculations of the position of the new planet in outer space are to be made in future.

Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

Civil Defence

Canada's civil defence organization now has a consolidated communications system stretching from St. John's, Nfld., to Victoria, B.C., as a result of circuits established by the communications organizations comprising the Trans-Canada Telephone System.

The new National Attack Warning System was turned over to civil defence authorities on April 1. The network provides inter-communication between all 10 provincial capitals and 19 other major Canadian cities or target areas, as well as the five air defence command control centres in Canada. A single control officer can give or receive messages to all or any one of the 34 stations on the system.

Existing long distance telephone circuits could be utilized when required. When not in use, they serve as regular long distance circuits.

Key centre for the 34-point network is at St. Hubert, Que., where the senior warning control officer works closely with air defence command headquarters. Any alert received by the base is immediately passed on to the civil defence officer who can then order the communications system energized by alerting The Bell Telephone Company of Canada at Ottawa.

Kept abreast of all new developments by the air defence command personnel at St. Hubert, the senior warning control officer can then report detailed information to the coordinators at the provincial capitals or direct to any other city on the network. In the event of a local attack for emergency the coordinator at any point can relay details back to the control centre at St. Hubert.

While 34 points were established on the network at the time of the turn-over, the facilities can be easily expanded to other centres virtually anywhere in Canada.

McAvity's 125 Years in Business

T. McAvity & Sons Limited is celebrating its 125th birthday in 1959.

The Company, now described as the second-biggest industry in the Maritimes (i.e. second to the DOSCO operation), started in 1834 in Saint John, N.B., as a hardware and drygoods business. It soon branched into the working of brass for ship parts needed in the shipbuilding industry in Saint John.

This early growth was accomplished by founder Thomas McAvity and his six sons. The business is still a family-owned enterprise, headed by President G. Clifford McAvity.

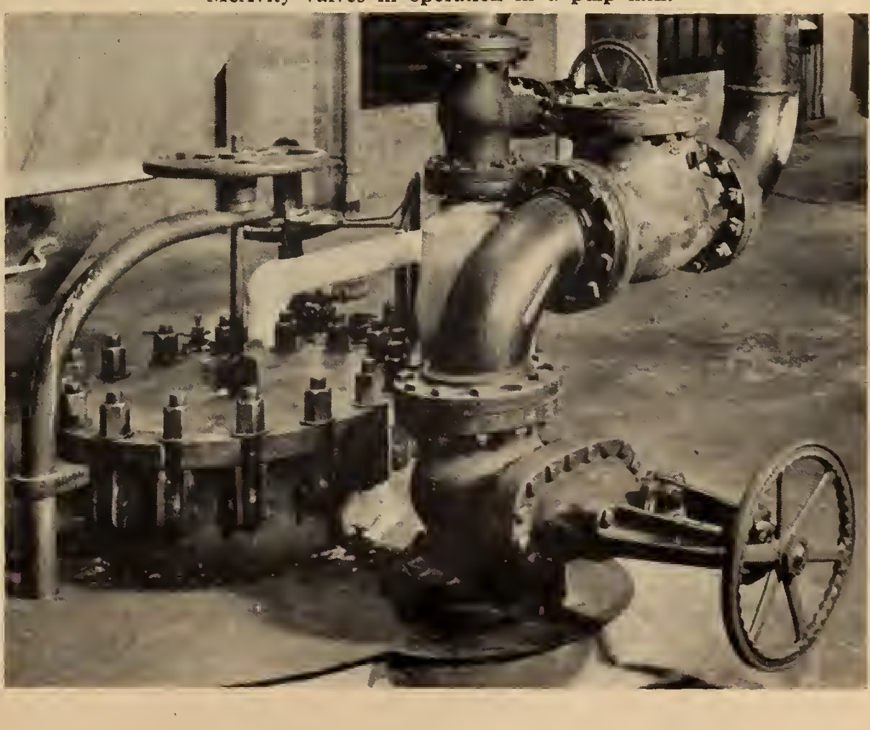
The brass and iron foundries began modestly, but grew rapidly. In 1879 the first valve was produced. Now, with 550 employees, the company is marketing across Canada, supplying valves in bronze, iron, steel, and aluminum for all services, pressures and temperatures. These products are fabricated in the 10-acre Saint John plant, along with fire hydrants, and corporation brass for municipalities.

The range of products has expanded, steadily and profitably. The largest expansion has been seen since World War II.

This adaptability has been of special service in the pulp and paper field. Metallurgical research and technical control of alloys allowed the company to provide high-nickel alloy castings and nickel-containing stainless steel cast valves able to withstand acid conditions occurring in that industry, and in others.

Extending applications for special purposes, McAvity entered the atomic energy field, to design, develop and manufacture special stainless steel valves of a type not previously made in Canada. They are used in the NRU reactor, the Canada-India reactor, and the current NPD project. Pressure ratings vary from low to 1,750 p.s.i., and temperature con-

McAvity valves in operation in a pulp mill.



ditions have been known to reach 550°F.

McAvity products will be found as far west as Vancouver, used in the fields of general contracting (buildings), municipal contracting (water and sewage systems), power developments, shipbuilding, mining, plumbing and heating, railways, and the petroleum industry.

The plant in Saint John includes brass, iron and aluminum foundries, as well as machine and assembly shops.

In the iron foundry, castings weighing up to 1,200 pounds are produced regularly, while occasionally a casting weighing as much as 4,000 lb. has been produced. Mechanization of the foundry has been undertaken when necessary. New foundry installations handle over 70% of output.

Branch offices and warehouses are located in Montreal, Toronto, Winnipeg and Calgary, and there are resident representatives and salesmen at strategic points across Canada, as well as distributors and jobbers. A Western manufacturing plant, T. McAvity and Sons (Western) Limited, Medicine Hat, Alta. is manufacturing fire hydrants, valves, and water works specialties.

What Goes On

Foreign Trade Service

As part of the efforts of the Department of Trade and Commerce to promote trade between Canada and other countries, a series of booklets is being produced providing up to date information on trade opportunities in various areas.

The basic material is compiled by a Trade Commissioner in the territory concerned, and the booklets are designed for distribution to interested Canadian manufacturers and exporters.

Copies are available from the Foreign Trade Service, Ottawa, on request. Venezuela, Rhodesia, Nyasaland, and Ireland have been dealt with in the series.

B.C. Budget for 1959

From the British Columbia budget presented in February to the legislature, these items can be noted.

The Pacific Great Eastern Railway: Having extended its regular passenger service last October to Dawson Creek and Fort St. John, the PGE railway made a substantial operating profit in 1958. Allowance was made in the budget for further improvement required in the line to handle the increased traffic.

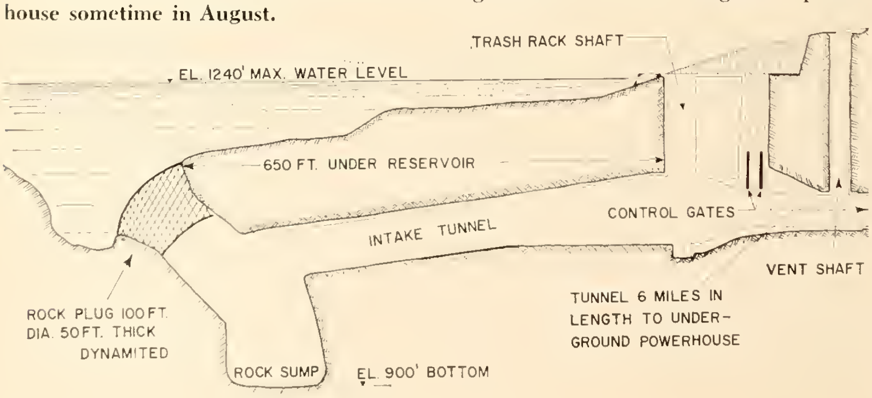
British Columbia Toll Highways: The Deas Island tunnel, forming part of the Fraser delta system, is expected to be in operation by the middle of 1959. Work has started on the highway connecting the Deas Island tunnel with the Oak Street bridge.

The Forest Industry

British Columbia's forest industry is experiencing a "surplus market condition" for its products because demand "has not yet fully materialized" for the output of its expanded mills.

President Peter T. Sinclair of Crown Zellerbach Canada Limited made this statement recently. He called for the utmost vigilance in 1959 in resisting operating cost increases and for more vigorous marketing activities.

Chute-des-Passes. A milestone on the Aluminum Company of Canada Ltd., 1,000,000-hp. Chute-des-Passes power project in Northern Quebec was successfully passed when explosives shattered a 30,000-ton rock plug and dropped the pieces into a pit dug out of the tunnel floor below. Removal of the plug cleared the way for water from the reservoir to enter an intake tunnel. There a temporary concrete barrier behind the control gates prevents premature flooding of the six-mile long power tunnel which will deliver water to electric generators in an underground powerhouse sometime in August.



RCAF Anniversary

This year the RCAF celebrating its 35th anniversary, has these milestones to recall.

Formed on April 1, 1924, it grew from 323 members to 906 in eight years.

Reduced in membership and operation during the depression, during World War II the RCAF grew from 4,061 men and a handful of outdated aircraft to a force of 206,000 men equipped with craft of the latest training and operational types.

The RCAF reverted to a peacetime footing. The few units retained resumed the prewar activities of aerial photography and air transport, including mercy flights. There was a search and rescue organization fulfilling the commitment to International Civil Aviation Organization.

The RCAF received its first jets in 1948, Vampires.

The RCAF transport element, assisting UN Forces in Korea, flew 600 round trips, to Japan, carrying personnel and freight.

The RCAF undertook training of aircrew for other NATO nations and Canada contributed a 12-squadron air division for NATO's integrated forces in Europe.

1953 saw the CF-100 go into squadron service with the RCAF for duty with Air Defence Command.

Emphasis placed on early warning and interceptor control system, produced in 1954 the Pinetree Line, jointly built. The two other warning lines went into operation in 1957.

An early 1959 announcement said the DEW line operational positions were to be manned by the RCAF.

Today the RCAF operates 40 regular force and auxiliary squadrons, 21 of them being regular force fighter and interceptor units. In Canada, nine CF-100 all-weather squadrons are on round-the-clock guard, and overseas four CF-100 and eight F-86 squadrons are serving with NATO. On this continent, under NORAD, the RCAF and the USAF operate as one to protect North American airspace, while retaining their individual identities. Three squadrons equipped with Argus and Neptune aircraft are protecting the coast lines east and west.

The introduction of the BOMARC missile and SAGE into the Canadian air defence system brings the RCAF to the "doorstep of the missile age".

Concrete Pipe Specifications

There is a new revision to the A.S.T.M. specification designated as C76-57T for reinforced concrete pipe conduits. D. H. Perkins, managing director, Ontario Concrete Pipe Association, commented on this recently, and information is available from his office at 60 Harbour St., Toronto 1, Ontario.

Oil Transportation Study

Cost of transporting Alberta viscous crude oil by pipeline may be favourably affected by a study being made by Alberta Research Council scientists.

Some Alberta oil which tends to adhere to the pipe wall requires high-cost pumping power. But pilot model tests, and computations, show that if water is introduced into a viscous oil pipeline, it forms a moving layer between the oil and the pipe wall. The oil is transported in a moving pipe of water, or in a "lubricated" pipe, and therefore needs less power. The water, with a relatively low viscosity, occupies the region of maximum frictional resistance at the pipe wall.

Further tests with the small scale pipeline may be followed by field tests in co-operation with an operating pipeline company.

Air Control

The Department of Transport's most recently established area control centre is located at Goose Bay, Labrador. Its purpose is to provide traffic control service to aircraft, civil and military, which operate in the north-easterly latitudes.

Goose Centre works together with the RCAF, who operate approach control and tower units, to provide traffic control service. It also provides control services to aircraft which operate on a controlled airway originating at Gander, Nfld., and terminating at Frobisher, N.W.T. In addition, oceanic control service is provided for the area between Greenland and Labrador.

Halifax Redevelopment

The housing project at Mulgrave Park, in Halifax, is described by Earl A. Levin, in the January issue of *Habitat* as "part of a redevelopment program which may be the most important experiment in urban redevelopment so far undertaken by any Canadian city." The full program involves not only housing of 350 families at Mulgrave Park, but redevelopment of a part of the city's business district, with financial assistance from the Federal Government under the National Housing Act.

The area to be vacated and later redeveloped contains a mixture of rundown commercial and residential buildings, covering about ten blocks of the business section. The 351 dwelling units will be contained in two eight-storey apartment blocks, one four-storey walk-up, and the balance in three-storey buildings containing apartments and maisonettes. The final form of the commercial redevelopment has not yet been determined. Cost of acquisition and clearing of land will be shared by Halifax and Federal governments.

B.C. Forest Survey

The British Columbia government Forest Service has produced and published a report, "Continuous Forest Inventory of British Columbia", which gives some new statistics of interest to government and to the forest industries.

In the province forestry is the primary industry, accounting for 40 per cent of the economy, and dedicated to sustained forest production.

The 118 million acres of commercial forests is equal to the total commercial forest area of the twelve western states of the United States.

Today, the government reports, the concept of sustained-yield is the industry-wide concept of operation, with more than 5 million acres of productive forest land managed by private industry. The Crown manages another 32 million acres.

Industry and Education

Evidence of the increasing interest of industry and commerce in higher education is observed by the Industrial Foundation on Education (170 University Ave., Toronto 1).

The giving plans of companies have been analyzed, with the cooperation of the companies, and a report is available. It will serve as background information for the guidance of any companies interested in setting up new, or modifying existing, programs of financial assistance to higher education.

The 127 companies reporting represent a fairly complete cross-section, and provide over fifty per cent of the total amounts contributed directly to universities by industry and commerce in 1957.

Of the total grants contributed to higher education in the survey group, the allocation to capital expenditure and unrestricted use represented the largest proportions—58.5% and 14% respectively. Other allocations were: student aid, 10.1%, special applications, 6.1%, research, 5.1%, and scholarship supplementary grants, 4.3%.

With the number of employees used as a measure of company size, the average amounts of grants of all companies was found to be $15.00 per employed person.

Copies of the report can be obtained from the Foundation at cost of $2.00 each.

Microwave link. Reflectors now completed at Cape North, N.S., and Red Rocks, Nfld., by Canadian National Telegraphs are part of the link to go into service in June, bringing Newfoundland into the cross-Canada microwave network. The system will provide three channels of communication into Newfoundland from the mainland, one each for Canadian Broadcasting Corporation television programs, for C.N.T. telephone and telegraph service, and for use as a standby. In the opposite direction, there will be one channel for commercial traffic and one standby which can be used for TV on occasion.

Month to Month

News of the Institute and the Profession

COMMENT
CORRESPONDENCE
ELECTIONS
AND TRANSFERS

CONFEDERATION

There have been no developments since the report which appeared in the April *Journal*. However, a comprehensive report is shown in the annual report of the Institute which has been printed and circulated to all members.

R.C.E. Corps Reunion

There will be a "once in a lifetime" Dominion wide reunion of the Corps of the Royal Canadian Engineers in Toronto on June 12, 1959. This is an officers' reunion, and a testimonial dinner to the Colonel Commandant, Brigadier J. L. Melville, C.B.E., M.C., C.D.

Information can be obtained from W. K. Clawson, P.O. Box 217, Sta. K., Toronto.

The date has been arranged to tie in with the E.I.C. annual meeting in Toronto when many Sappers will be on hand.

Another event is the D-Day Ball, of the Officers Wives Auxiliary, 2 Field Engineer Regiment, R.C.E., on Thursday, June 11, 1959.

President's Tour

President Kenneth F. Tupper, continuing his tour of the Branches, visited Cape Breton on February 13. In the photograph; William Dodson, branch chairman, Dr. Tupper, past chairman Vince Palmer, and Councillor M. R. Campbell.

Eighty members and wives and friends attended a dinner held on this occasion.

Annual General Meeting, E.I.C.

Notice is hereby given, in accordance with the by-laws, that the annual general meeting of the Engineering Institute of Canada for 1959 will be convened in the Concert Hall of the Royal York Hotel, Toronto, Ont., on June 8, 1959, at 10.00 a.m.

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 March 21, 1959.

Member: M. L. Bassan, Montreal; B. R. Boardman, Toronto; O. Brody, Montreal; J. F. Godsell, Saint John; Harris-Lowe, Queenston; G. J. Hebert, Cap de la Madeleine; R. W. Karle, Brazil; M. O. Kellogg, Toronto; J. Leitersdorf, Hamilton; R. F. McCune, Montreal; D. J. McDougall, Montreal; T. J. F. Pavlasek, Montreal; H. R. Switzer, Montreal; J. C. Thompson, Montreal; E. W. Weaver, Sudbury.

Junior: A. H. Banani, Elliot Lake; D. L. Bertrand, Sherbrooke; D. G. Quinlan, Sorel; A. D. Taylor, Sault Ste. Marie.

Junior to Member: W. N. Brown, Quebec; C. A. Dagenais, Montreal; W. D. Dawson, Montreal; M. B. Ferman, Montreal; J. Granger, Montreal; A. G. Hoyt, Trenton; S. Narvey, Toronto; J. M. Rosborough, Temiskaming.

Student to Junior: J. M. Robic, Montreal; D. Rudberg, Montreal.

STUDENTS ADMITTED

University of Toronto: B. L. Allan, G. N. Bird, D. E. Blachford, G. C. Bonham, E. C. Budicky, D. B. Coveney, J. H. R. Crumb, I. G. Cumming, W. D. Farwell, J. I. Fisher, J. F. Green, R. G. Hannaford, W. R. Hayworth, R. M. Herod, M. K. Ho, D. M. Kaminker, G. A. Look-kong, V. Lum, W. H. Mak, F. J. Reinders, S. B. Urving, P. Woon.

Nova Scotia Technical College: S. M. Bishop, W. J. Campbell, W. Chan, B. J. Cutcliffe, H. K. Giddens, D. L. Greenwood, R. G. Hache, E. A. Hachey, Y. K. Leung, R. L. McClare, A. N. S. O'Rourke, D. J. Skinner.

Saint Mary's University: P. B. Carroll, M. P. Chan, D. J. Chiasson, A. K. Connors, J. G. Flemming, G. W. Hill, F. G. Mason, H. A. L. McGuire, J. V. Nolen, G. P. Pothier, R. L. Sheehan, R. E. Wayland.

Laval University: R. Caron, R. Doucet, M. Garon, G. Lamontagne, C. Martel, P. Michaud, R. M. Pelletier, A. Thivierge.

University of New Brunswick: D. W. Betts, J. J. Gorman, N. M. Hoyt, G. R. Marquis, A. Venczel.

University of British Columbia: C. G. Meckling, W. S. Rodenchuk, L. J. Trabert, R. V. M. Zahar.

University of Manitoba: A. Boychuk, G. G. Duncan, B. K. Stinson, T. M. Syposz.

University of Alberta: T. R. Horn, R. W. Patterson, H. G. Tym.

McGill University: F. J. Miller, A. Robinson.

St. Francis Xavier University: T. P. Kieser, M. A. Pettigrew.

Mount Allison University: T. Havas.

Cambridge University: C. D. Thompson.

University of Saint Joseph: V. Leger.

Student of A.P.E.O.: A. Gonnsen.

University of Toronto: H. B. Lett, M. A. Mann.

Application through Association

By virtue of the co-operative agreement between the Institute and the Associations the following elections and transfers have become effective.

SASKATCHEWAN

Members: F. D. Hamblin, R. Hood, B. D. Olafson, W. Stemmler, J. J. White; **Juniors:** P. J. Bonser, A. W. Cliteur, G. E. Cummings, E. H. Gerretsen; **Junior to Member:** D. B. Dundee, M. Kesmarky, E. M. Misfeldt, J. B. Street; **Student to Member:** J. W. MacNeill; **Student to Junior:** N. J. Antaya, B. L. Kilpatrick, J. E. Lovecky, D. E. Mortin; **Students:** R. A. Baumgartner, K. A. Birch, D. G. Charrett, A. Jmaeff, R. G. Lightfoot, D. J. McCuaig, W. Nemanishen, P. A. M. Poliquin, S. M. Quilty, K. J. Serdula, R. S. Sins (Miss), W. A. Tapuska.

NEW BRUNSWICK

Member: J. J. Pader.

SEVENTY THIRD

ANNUAL GENERAL AND PROFESSIONAL MEETING

OF

THE ENGINEERING INSTITUTE OF CANADA

JUNE 8, 9, 10, 1959 ROYAL YORK HOTEL TORONTO, ONT.

REGISTRATION

Advance registration through E.I.C. Headquarters closes May 23.
Registration opens 3:00 p.m. June 7, and continues at 9:00 a.m. June 8, 9 10, 1959.

ACCOMMODATION

The Royal York Hotel is headquarters, with 500 rooms reserved for E.I.C. members and guests.

TECHNICAL PROGRAM

The technical program is listed on the following two pages.

LADIES' PROGRAM

There's promise of a "new and different" program of activities for the ladies attending the meeting; also:
9.30 a.m. daily, Ladies' Coffee Hour
9.30 a.m. Tuesday, Engineers' Wives Meeting.

TORONTO DIARY

Events for all four days at the Royal York Hotel are listed on the back page of this program.

• ● •

COMMITTEE

Chairman:	E. R. Davis
Vice-chair:	M. P. Whelen
Sec-treas:	G. F. R. Norton
Entertainment:	W. A. Bentley
Finance:	C. E. Potter
Meeting Arrangements:	H. B. Tryhorn
Plant Visits:	G. F. R. Norton
Publicity:	H. Fealdman
Reception:	D. D. Whitson
Transportation:	C. MacInnes
Technical Papers:	B. Hardcastle

Convenor, Ladies Program: Mrs. A. C. Davidson
Chairman, Toronto E.I.C. Wives Auxiliary: Mrs. W. L. Hutchison.

Please read the following three pages

TECHNICAL

MONDAY, JUNE 8

1:30 p.m.

Hydraulic Problems in Connection with St. Lawrence River

H. W. Lea

First Cyclone-Fired Boilers in Canada and some Aspects of their Early Operation

E. K. Akin

Head-Loss Coefficients for Niagara Water Supply Tunnels

J. B. Bryce; R. A. Walker

2:30 p.m.

Design & Erection Features of the Vertical Lift Bridges for the St. Lawrenee Seaway

W. G. H. Holt

A Gas Turbine Power Plant for Locomotives

D. C. McPhail

Photography & Electronics as Tools in Hydraulie Work

K. W. Gent; I. W. McCaig

EIC ANNUAL MEETING, 1959

3:30 p.m.

Backwater Computations for the St. Lawrenee River Project—Part I—Hydraulie Engineering Aspects of Computation—

H. M. McFarlane

The Use of Fly Ash in Concrete

I. Mustard; C. MacInnis

A Method of Determining Power Potential of Rivers with Many Reservoirs & Power Plants

G. S. Cavadais

4:30 p.m.

Backwater Computations for the St. Lawrence Seaway Project—Part II—Calculations on the Ferranti Digital Computer—

C. C. Gotlieb

Voluntary Standards — Vital to Progress

J. A. Reid

Tests of Hydraulic Turbines — An Appraisal

J. J. Traill

TUESDAY; JUNE 9

9:00 a.m.

Normal Mode Analysis of Beams of Non-uniform Cross-section

S. Ranta

Precast Concrete as an Aid to Winter Construction

C. R. Crocker; A. W. Smith

A Study of the Hazards of Electric Shock (with partieular reference to 60 cycles)

A. R. Morse

10:00 a.m.

Some Considerations in Steam Power Plant Design

A. G. Christie

Littoral Drift in Lake Ontario Harbours

R. J. Kennedy; A. Brebner

Magnetic Amplifier Control for Reversing Hot Mill Auxiliaries

R. L. Duke; L. R. Hulls

11:00 a.m.

Electro-Hydraulic Governors at Beechwood Generating Station

P. G. Fazzari; G. H. D. Ganong

PROGRAM

Experimental Studies of the Effect of Blasting on Structures
A. T. Edwards; T. D. Northwood

Edmonton Installs Canada's First Oil-filled Pipe Cable System
C. Z. Monaghan; W. J. Pardy

2:00 p.m.
Headquarters Computation Centre for Ontario Hydro — A Symposium
W. H. Sanders; S. J. Crossman; J. Rywak; H. R. Davis

2:00 p.m.
Design & Construction of Whitedog Falls and Caribou Falls Generating Stations
N. St. Claire Haines

3:00 p.m.
Silver Falls Generating Station
P. R. Stratton; C. T. Bath

River Control in the International Rapids Section — The St. Lawrence Power Project
K. A. Henry

4:00 p.m.
St. Lawrence Power Project — Rehabilitation
J. H. Jackson

7:00 p.m.
138 KV Undersea Cable Across Georgia Strait
T. Ingledow

Engineering For Export
R. A. Frigon

Processing of Low Grade Iron Ore Using Natural Gas or Petroleum
P. E. Cavanagh

3:30 p.m.
Graphite in the World Nuclear Power Program
The late Sir Claude Gibb (presented by H. B. Topham)

WEDNESDAY, JUNE 10

9:00 a.m.
Special Features of the Brandon Generating Station
A. C. Blue; W. P. London; E. M. Scott; P. A. Pasquet

The Interconnected Power Systems of Nova Scotia and New Brunswick
G. D. Mader

Geological Features & Foundation Treatment at the Beechwood Development
J. D. Mackenzie; E. L. Brown

10:00 a.m.
The Humber Sewage Treatment Plant
R. L. Clark

Industrial Uses for an Auxiliary Low Frequency Power Supply
G. L. Tiley; E. Oldfield

Beauharnois No. 3 Construction & Development
Y. deGuise; C. Forest

11:00 a.m.
Development of Water Resources in Ontario
A. E. Berry

EIC TORONTO, JUNE 8, 9, 10

The Development of an Electric Detector of Flaws in Paper
M. P. MacMartin; N. L. Kusters

Economics of Byproduct Power Development
W. P. London; W. M. Newby

2:30 p.m.
Economic Aspects of the Seaway — A Panel Discussion
E. W. Kierans; R. Vaillancourt; P. Camu; H. Massue; D. Kerr

Preprints of many of the above papers are available from Headquarters, 2050 Mansfield Street, Montreal, at a cost of 50 cents per paper.

ANNUAL EIC MEETING

SUNDAY, JUNE 7

9:30 a.m. Education Conference (Deans) Branch Officers' Conference
10:00 a.m. Council Meeting
12:30 p.m. Joint Luncheon, all conferences
2:00 p.m. Continuation of Conferences
3:00 p.m. Committee on Technical Operations
8:30 p.m. Atomic Energy Film

MONDAY, JUNE 8

9:30 a.m. Education Conference continues
10:00 a.m. Annual General Meeting
12:00 noon Muriel's Room
12:00 noon Authors' Luncheon
2:00 p.m. Students' Conference
3:30 p.m. Policy Committee
6:30 p.m. Reception Muriel's Room
7:00 p.m. Dinner
9:00 p.m. Open House

TUESDAY, JUNE 9

7:45 a.m. Authors' Breakfast
9:30 a.m. Professional Development Committee
10:00 a.m. New Council Meeting
10:00 a.m. Consulting Engineers, Directors
11:30 a.m. Professional Development Lunch
2:00 p.m. Professional Development Forum
2:00 p.m. Students' Conference, cont'd.
2:00 p.m. Plant Visits
2:30 p.m. Consulting Engineers, Annual General Meeting
7:00 p.m. Consulting Engineers, An- open to all.
9:00 p.m. Muriel's Room, Refreshments
9:30 p.m. Cabaret—entertainment

WEDNESDAY, JUNE 10

7:45 a.m. Author's Breakfast
9:00 a.m. Joint ASME-EIC International Council
12:00 noon Muriel's Room, Refreshments
12:30 p.m. Luncheon, prizes and medals
2:30 p.m. Faculty Advisers' meeting
6:30 p.m. Muriel's Room, reception
7:30 p.m. Annual Banquet
After Banquet—informal reception
10:00 p.m. Annual dance
10:00 p.m. Open House, Muriel's Room

THE ENGINEERING INSTITUTE OF CANADA

NEWS OF THE
Associations and Corporation

Information received through co-operation of the provincial organizations.

ONTARIO

President McQueen Comments. From "The Professional Engineer" March, 1959, an abstract.

"We cannot help but continue with the building both of ourselves and our profession." They, of course, go hand in hand, because if we enlarge on our own capacity for life we automatically build and extend the engineering world which is so dear to us.

Twenty-five years ago the aim of the A.P.E.O. was to have all engineers become members of the Association and so be licensed to practice under the Act. It may be said that this objective has now been achieved. The present task of the A.P.E.O. is to make their members act like professional people. We must grasp clearly the essential features of professional conduct. Our code of ethics is excellent but on examination it can hardly be said to require more of us than a standard of performance. If we continually build ourselves, developing our essential integrity and that inner something which is in each of us, we must go beyond the simple requirement of the Code. The mainspring of professional behaviour is, in part, simply love of one's work, so that our best is freely given, and in so doing, deep pleasure and satisfaction is obtained.

QUEBEC

Officers Elected

W. J. Riley P.Eng., of Montreal, was elected president of the Corporation of Professional Engineers of Quebec at the Annual Meeting held at the Chateau Frontenac, Quebec. He succeeds Guillaume Piette, P.Eng., of Quebec City.

J. G. Chenevert, P.Eng., Montreal consulting engineer, was elected vice-president and O. S. Gislason, P.Eng., of Arvida, was made honorary secretary-treasurer of the Corporation.

New members elected to the Corporation's Council are: Gilles Sarault, P.Eng., consulting engineer of Quebec City, A. J. Groleau, P.Eng., Area Plant Manager, The Bell Telephone Company of Canada, Montreal, and H. J. Racey, P.Eng., consulting engineer of Montreal.

Other councillors include Arthur Piche, P.Eng., Guillaume Piette, P.Eng., immediate past president, of Quebec City, and G. N. Martin, P.Eng., of Montreal.

William J. Riley is chief engineer of Sperry Gyroscope Company of Canada Ltd.

Born in Chicago, Ill., he received all of his education in Montreal. Mr. Riley

W. J. Riley, P.Eng.

graduated from Loyola College High School in 1937, and entered McGill University's engineering faculty where he remained until 1940 when he answered the call to arms. During the war years, Mr. Riley served with the Royal Canadian Artillery in England and North Western Europe and retired with the rank of captain in 1945. He was awarded the Military Cross and the Canadian Forces Decoration. He returned to McGill in 1945 and in 1948 obtained a degree of bachelor of engineering with honours in Mechanical Engineering.

He joined International Harvester Company Ltd. as product engineer responsible for the design of engines in the company's truck division of Chatham, Ont.

In 1950, he joined Canadian General Electric Company at Montreal as quality control engineer and the following year was made divisional engineer of the Montreal works. He was promoted in 1952 to the post of manager, engineering, of CGE's Montreal works and the same year he became assistant works manager.

In 1953, he joined Sperry Gyroscope (Ottawa) Ltd. as works manager and remained there until 1955 when he was called to the Montreal plant as chief engineer of Sperry Gyroscope Company of Canada Ltd.

In his present position, he is responsible for development engineering, product engineering and quality control in connection with instrumentation and controls.

Mr. Riley is a councillor of The Engineering Institute of Canada, a member of the American Management Association, The Canadian Aeronautical Institute and the Society of Automotive engineers.

Until last year, he was a member of the Canadian militia and retired to the supplementary reserve with the rank of major.

ALBERTA

Registrar Appointed

The Association of Professional Engineers of Alberta appointed Ivan G. Finlay, P.Eng., registrar of the Association. It is the first time the position is to be filled by a full time appointee.

Mr. Finlay was born and educated in Alberta, graduating from the University of Alberta in 1950 with the degree of Bachelor of Science in Electrical Engineering. He subsequently joined the Electrical Inspection Branch of the Province of Alberta and in 1954 was appointed assistant chief electrical inspector. In 1956 he was promoted to the position of chief electrical inspector.

He has been active in technical affairs and is a member of the executive of the Edmonton Branch of the Engineering Institute of Canada. He is also a member of the Edmonton Electric Club and the International Association of Electrical Inspectors.

Annual Meeting

The annual meeting of The Association of Professional Engineers of Alberta took place in the Palliser Hotel, Calgary on April 3rd, 1959.

Technical papers on the program were: "The Impact of New Developments in Chemistry" by Dr. P. E. Gishler; "New Developments and Applications in Physics" by J. M. Dewey; "Advances in Mathematical Techniques and the Development of High Speed Computers" by Dr. R. G. Racicot; "Social Implications of Recent Scientific Advances" by Rev. F. S. Morley, and "The Engineer of the Future" by John H. Fox.

Engineer-Senator

J. A. Buchanan, P.Eng., has been appointed Alberta's new senator.

Mr. Buchanan came to Edmonton in 1910 after graduating in civil engineering from the University of Toronto. He was a surveyor, and later entered the construction field. In 1931 he organized the Buchanan Construction Co. Ltd., of which he is president.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

James A. Dick, M.E.I.C. died on January 20th, 1959.

He was born on July 27, 1882 in West Calder, Scotland.

From 1906 until 1938 he was mainly employed in railway and contracting engineering in Ontario and with the Gatineau Power Company in Ottawa.

During the war he was assistant director of civil engineering maintenance for Department of National Defence (Navy) retiring as director from that position in 1954.

Edward Ponsonby Corner, M.E.I.C. of Kenogami, Que., died on January 6, 1959.

Born on March 10, 1888, in Georgetown, British Guiana, he received his training as a mechanical engineer in Glasgow, Scotland. In 1919 he was sent to the British West Indies by Fawcett Preston where he was the agent for sugar machinery.

He came to Montreal during 1930 where he was Quebec representative for Hamilton Gear and Machine Co. Ltd. until his retirement in 1954. Afterwards he was employed as gear specialist with the Canadian International Paper Co., at Kenogami, until 1956.

John A. MacArthur, M.E.I.C. died on December 11, 1958.

He was born April 15, 1902 in Glasgow, Scotland and received his B.Sc. degree in engineering from the University of Glasgow in 1924.

Mr. McArthur came to Canada in 1929. He joined the Abitibi Power and Paper Company Ltd. at Fort William, Ont., after varied experience with chemical, engineering and shipbuilding work.

From 1944 he was connected with Sherbrooke Machineries Ltd., Longlac Pulp and Paper Company Ltd., in Toronto, and with the Stadler, Hurter and Company of Montreal.

In 1954 he founded his own consulting firm with Alfred Malkin in Montreal.

Gordon Wesley Parkinson, M.E.I.C., chief of the PFRA design division, died on January 23, 1959.

Born at Mount Sicker, B.C., he graduated from the University of Saskatchewan in 1929 as an engineer, and later received his master's degree at LeHigh University in Bethlehem, Pa.

After working for various construction firms, he became instructor on the staff of the Saskatoon technical school from 1936 until 1939, later becoming lecturer and assistant professor at the University of Saskatchewan.

During the Second World War, he carried out research work for the National Defence Department in connection with floating docks and airfields built of ice. In 1946 he left the University to join the PFRA. His most important work there was in the South Saskatchewan River project for which he was in charge of engineering design.

Walter C. Griesbach, M.E.I.C., consultant engineer for the Foundation Company of Canada Limited, died February 16, 1959.

He was born in Collingwood, Ont., on July 23, 1891. He graduated from Queen's University in 1912 with a B.Sc. degree in civil engineering.

Following his graduation he became assistant engineer with the Department of Public Works of Canada, and in 1918 joined the Foundation Company of Canada with whom he was chief engineer until 1958.

He was awarded the Gzowski Medal of the Engineering Institute, and was the inventor of the multi-cylinder pneumatic caisson.

Joseph Henry Bower, M.E.I.C., died on January 1, 1959 in Toronto.

He was a graduate of the University of Toronto in 1914 with a B.A.Sc. degree.

He was at one time secretary to the Hydro-Electric Enquiry Commission, and in 1949 he became superintendent to the hospital for sick children in Toronto. He retired from this position in 1957.

R. G. Smalley, M.E.I.C., died in Vancouver, B.C. on September 13, 1958.

He was born in London, England on November 21, 1907 coming to Canada in 1910 and to Vancouver in 1930. He worked with Wilson Engineering Corp., Cambridge, Mass., and studied structural engineering.

He joined the Western Bridge & Steel Fabricators Ltd., in 1938 as assistant chief draughtsman. He was chief draughtsman from 1951 until the time of his death.

Earlier he had worked in structural engineering at Port Arthur, and with other organizations in Vancouver. He held a commission in the R.C.N.V.R.

John A. Shaw, M.E.I.C. of Hudson Heights Que., retired C.P.R. engineer, died on December 29, 1958.

He was a graduate of McGill University in 1899 with a science degree in electrical engineering. He worked for the Montreal Light, Heat and Power Company as assistant for the next five years.

In 1904, he joined the Canadian Pacific Railway Company and in 1915 was appointed general electrical engineer for the company. His subsequent duties included the supervision of mechanical installations in company plants and office buildings. He retired in 1946.

Joseph Nicholas de Stein, M.E.I.C. died on January 19, 1959, in Regina, Sask.

He was born in St. Petersburg, Russia. on August 28, 1880, and received his engineering degree in Germany, at Stuttgart University.

In 1905 Mr. de Stein joined the Grand Trunk Pacific Railway in Canada. About 1920 he established his own business, now known as the Western Drafting and Blue Printing (Western Branch) Instruments Ltd., in Regina, Sask. He retired from the firm in 1951.

He was a member of the Regina town planning commission when it was formed in 1930.

Dr. John A. Stiles, O.B.E.,M.E.I.C., died in Ottawa on November 29, 1958. Since 1919 he worked with the Boy Scout Movement, first as assistant Dominion commissioner. He was appointed Dominion commissioner in 1930. He retired in 1946 as chief executive commissioner.

A graduate of the University of Toronto, he was awarded the O.B.E. in 1935 and in 1946 was honoured with the degree of Doctor of Science by U.N.B.

His work before 1919 was that of dean of applied science at University of New Brunswick.

E.I.C. ANNUAL MEETING 1959

ROYAL YORK HOTEL, TORONTO, JUNE 8, 9, 10.

John Jeffery Hanna

PRESIDENT

THE ENGINEERING INSTITUTE OF CANADA

1959 - 1960

JOHN JEFFERY HANNA, M.E.I.C., of Calgary, Alberta, president-elect of The Engineering Institute of Canada is an engineer who has been associated with Alberta's oil industry for over thirty-five years.

Mr. Hanna is a graduate of the University of Toronto, having received the B.A.Sc. degree in civil engineering in 1914. His work has been continually in the West since he joined the engineering department of the City of Calgary, in 1914.

He served with the Canadian Engineers in the Expeditionary Force, from 1914 to 1919, attaining the rank of Captain.

Returning then to work for the City of Calgary, he was assigned special engineering work for two years on natural gas and general engineering. Then during 1920 and 1921 he was resident engineer for the City on the Hillhurst Bridge.

Mr. Hanna was with the Lethbridge Northern Irrigation District in 1921, and was resident engineer on the Old Man River flume.

His service for Imperial Oil Limited at Calgary Refinery was accomplished in the positions of construction engineer, mechanical superintendent, assistant refinery manager, and refinery manager.

Mr. Hanna's membership has been a considerable asset to the Institute and particularly to the Calgary Branch. He has served on many committees, as chairman and as councillor. With his membership dating from 1917, he is one of the most interested and best informed members of the Institute.

The Association of Professional Engineers of Alberta has received his support as a member of council, as vice-president and as president. He was its representative to the Dominion Council in 1955.

Mr. Hanna has actively participated in student guidance and educational reform for many years in Alberta. For both the Calgary Branch of the Institute and the Chamber of Commerce he has acted on local committees on education. He sat on the Professional Engineers Committee on Counselling and Education when a brief was submitted to the Senator Cameron Royal Commission.

Other services have also claimed Mr. Hanna's attention: he has been a member of the Chamber of Commerce for 18 years, a councillor and a committee chairman; a member and director of Rotary International, Calgary Club. He is chairman of the Finance Committee of the Calgary Branch of the Canadian Red Cross Society. He is in his second term as an alderman of the city of Calgary.

NEWLY ELECTED OFFICERS OF THE INSTITUTE

At the Annual Meeting, three vice-presidents and thirty-six 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.

R. B. Chandler, M.E.I.C., of Port Arthur, Ont., is elected a vice-president of the Institute representing the Province of Ontario.

Mr. Chandler has recently been appointed a member of the Lakehead Harbour Commission by the Federal Government. He retired as manager of the Public Utilities Commission of Port Arthur in 1954, having held that office from 1945. He then became a member of the Commission, and is now its chairman.

Earlier, from 1917-1923, he was with the C. D. Howe and Company, Port Arthur, as designing and supervising engineer, and as a consulting engineer and partner. He had completed his engineering studies at the University of Toronto in 1912, receiving a B.A.Sc. degree.

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

R. B. Chandler, M.E.I.C.

C. V. Antenbring, M.E.I.C., elected vice-president of the Institute to represent the Western Provinces, is president of Cowin & Co. Ltd., Winnipeg.

Mr. Antenbring studied at the University of Manitoba, graduating in 1926 in civil engineering.

He joined Cowin & Co. Ltd., in 1927 as a designer of reinforced concrete.

He is a former chairman of the Winnipeg Branch, and a former councillor of the Institute. He is also a past-president of the Association of Professional Engineers of Manitoba.

F. L. Lawton, M.E.I.C., chief engineer, power department, Aluminium Laboratories, Montreal, is elected a vice-president of the Institute, representing the Province of Quebec.

Mr. Lawton has acted in an engineering capacity on a number of major hydro-electric developments and projects.

He graduated in 1923 from the University of Toronto in electrical engineering. For the first eighteen years of his career he was successively with The Canadian Westinghouse Company, the Quebec Development Company, the Duke Price Company Limited, and its successor, Saguenay Power Company Limited. In 1941 he joined the Aluminum Company of Canada Limited as assistant chief engineer, and was named to his present post in 1948 with Aluminium Laboratories.

Mr. Lawton has served the Institute as a councillor, and he is a past-chairman of the Saguenay and Montreal Branches.

Nicholas Gritzuk, M.E.I.C., has been elected a councillor to represent the Yukon Branch of the Institute.

Mr. Gritzuk's experience has been in the Canadian North, in either the mining industry or associated with it, since 1934. After gaining a degree, B.Sc. (honours), in metallurgical engineering from Queen's University in 1945, he returned to the Central Patricia Gold Mine in northern Ontario. However, in 1946 he received the appointment of metallurgical and mill superintendent for a new Yukon venture, now United Keno Hill Mines Limited. In 1952, with the development of an associate company as an asbestos producer in northern British Columbia, the transport division of United Keno Mines Limited and Cassiar Asbestos Corporation Limited was established, based at Whitehorse, Yukon. Mr. Gritzuk was made manager of this function and a wholly-owned equipment sales subsidiary—the Territorial Supply Company Limited.

Commander P. F. Fairfull, M.E.I.C., superintendent of the Graving Dock at Esquimalt, B.C., has been re-elected to represent the Vancouver Island Branch on the council of the Institute for another two-year term. (Commander Fairfull's biography appeared in the June 1957 issue of the *Journal* in connection with his first election to this office.)

P. N. Bland, M.E.I.C., will represent the Vancouver Branch on the council of the Institute for a two-year term,

Mr. Bland has been since 1949 chief engineer of Canadian Sumner Iron Works Ltd., Vancouver. Mr. Bland joined the engineering profession through the Association of Professional Engineers of B.C. in 1933. He had worked with Sumner Iron Works in Vancouver and Washington for ten years. Since 1931 Mr. Bland's work has been with the Canadian Sumner Iron Works Limited, with the exception of a three-year period. His first appointment as chief engineer was made in 1937.

Mr. Bland served the B.C. Association as a member of the Board of Examiners, as a member of the editorial board and as a member of Council. He is a past chairman of the Vancouver Branch, E.I.C.

H. R. Hatfield, M.E.I.C., of Penticton, B.C., has been elected to represent the Central British Columbia Branch on the Council of the Institute.

Mr. Hatfield graduated from the University of British Columbia in 1928. In 1930 he joined the Interior Contracting Company Limited, at Penticton, working with this company until 1958, and attaining the post of president and superintendent. He is now a consulting engineer.

During the war years he spent a year with the R.C.A.F., and he acted from 1941 to 1945 as service and works engineer in the R.C.E. at Petawawa, Barriefield and Chilliwack.

Mr. Hatfield is a former chairman of the Central British Columbia Branch.

A. F. Brooks, M.E.I.C.

S. Barkwell, M.E.I.C.

A. F. Brooks, M.E.I.C., superintendent nitrate plants, Warfield Department, Chemicals and Fertilizers Division, of The Consolidated Mining and Smelting Company of Canada Limited, has been elected councillor of the Kootenay Branch of the Engineering Institute.

Mr. Brooks received his education in Montreal. He graduated from McGill University with a degree in chemical engineering in 1950, after having served with the R.C.A.F. from 1939 to 1945. While in the air force he was engaged in technical armament work in Canada and the European theatre; he attained the rank of Flight Lieutenant. Mr. Brooks joined Cominco at Trail, B.C. and in 1951 he became a research engineer in smoke and fume control work. He was assistant superintendent, phosphate plant, Warfield Department from 1956 to 1958 .

Mr. Brooks has been active in Professional Development Course programs of the Kootenay Branch. He was Branch chairman in 1955.

A. Howard Douglas, M.E.I.C., of Saskatoon, professor and head of the civil engineering department, University of Saskatchewan, Saskatoon, past chairman of

P. F. Fairfull, M.E.I.C.

N. Gritzuk, M.E.I.C.

P. N. Bland, M.E.I.C.

H. R. Hatfield, M.E.I.C.

the Saskatchewan Branch, 1949, has been elected to serve as a councillor for the Institute, representing the Saskatchewan Branch.

Mr. Douglas is a graduate of the University of Saskatchewan, 1931, with a degree of B.E. in civil engineering. He worked in the field of contruction and structural design with contractors, and in the bridge branches of the Ontario and the Saskatchewan departments of highways. He served for 4½ years with the construction engineering branch of the R.C.A.F. in Ottawa. He joined the staff of the College of Engineering at the University of Saskatchewan in 1947, and took over his present position in 1953.

He is a member and past president of the Association of Professional Engineers of Saskatchewan.

Stewart Barkwell, M.E.I.C., will be a councillor of the Institute representing the Winnipeg Branch.

Mr. Barkwell is a graduate of the University of Manitoba, 1940, with a B.Sc. degree in electrical engineering.

He joined Canadian General Electric that year. He spent three years in industrial engineering at the G.E. armament plant, at Peterborough, Ont. After service with the RCEME he returned to CGE power transformer section in design engineering. He joined the apparatus sales department in Winnipeg in 1950 and in 1955 was appointed utilities sales engineer.

Mr. Barkwell has been active with the E.I.C., serving five years on the executive of the Winnipeg Branch Electrical Section and as chairman of the Section in 1956. In 1957 he was appointed to the Electrical Engineering Division of the Committee on Technical Operations.

T. H. Newton, M.E.I.C., will be a councillor of the Institute representing the Edmonton Branch. He is the immediate past-chairman of the Branch.

Mr. Newton is president of T. H. Newton Engineering Ltd., Edmonton, and a graduate in civil engineering from the university of Alberta, class of 1948.

Earlier he has worked with Main, Rensaa and Minsos, Edmonton, and with the Lee Oil and Natural Gas Company, Edmonton.

D. B. McKillop, M.E.I.C., councillor-elect for the Lakehead Branch, graduated from Queen's University in 1929.

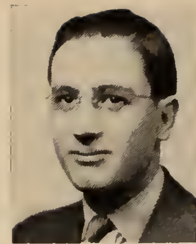
Since that time he has been employed in various capacities with the engineering department of Canadian National Railways.

He has recently been designated as Fort William representative on the Lakehead Harbour Commission soon to be established for the administration of a $7 million harbour facility being developed in conjunction with the St. Lawrence Seaway Development.

F. A. Orange, M.E.I.C., has been re-elected to a second term on the Council of the Institute, representing the Sudbury Branch. Mr. Orange is a design engineer with International Nickel Company at

D. B. McKillop, M.E.I.C.

F. A. Orange, M.E.I.C.



A. L. Furanna, M.E.I.C.

H. A. Gadd, M.E.I.C.

Copper Cliff. A biography appeared in the June 1957 issue of *The Engineering Journal* in connection with his first election to this office.

A. L. Furanna, M.E.I.C., has been elected a councillor of the Institute representing the London Branch.

Mr. Furanna is a graduate of Queen's University, 1939, with a degree of B.Sc. in electrical engineering. He has been associated with the Public Utilities Commission of London, Ontario since 1940, with the exception of three years of wartime leave. He was appointed chief engineer in 1949, which position he still holds, with that of assistant general manager.

Mr. Furanna's contribution to the work of the E.I.C. has been extensive: member of the executive, secretary-treasurer of the London Branch, vice-chairman, chairman, 1949, and chairman of the Profession Development Course.

Harry A. Gadd, M.E.I.C., will be the councillor representing the Port Hope Branch.

Mr. Gadd's engineering education was taken in England, including an engineering course at Rugby College of Technology and mechanical apprenticeship at British-Thompson-Houston Company, Rugby. Mr. Gadd came to the Canadian General Electric Company Limited in Toronto in 1923 and has been employed since that time by C.G.E.

Here his activities have included manufacturing, sales and engineering assignments. He is now manager, plastics engineering, C.G.E. plastics plant at Cobourg, Ont.

J. W. Dolphin, M.E.I.C., will be a councillor of the Institute representing the Kingston Branch. He is a former branch chairman.

J. W. Dolphin is head of the department of civil engineering, Royal Military College of Canada at Kingston. He is a graduate of the University of British Columbia, 1937, with a degree of B.A. Sc. in civil engineering.

Until the beginning of World War II he was employed by the Hydrographic Service. During the war he served the R.C.A.F. as a works officer and later as a navigator. When he returned to Canada in 1946 he was appointed lecturer at the University of Manitoba. Upon obtaining an M.Sc. degree from the University of Minnesota in 1948 he was named assistant professor of civil engineering at the University of Manitoba. In 1952 he joined the staff of R.M.C.

J. W. Millar, M.E.I.C., is the new councillor representing the Nipissing and Upper Ottawa Branch of the Institute.

Mr. Millar received the degree of B.A. from the University of B.C. in 1926 and that of B.A.Sc. in mechanical engineering from the same university in 1927. He had been associated with the Canadian Pacific Railway earlier, and after his graduation he worked until 1943 with C.P.R. in western Canada. From 1938 to 1943 he was general locomotive foreman at Vancouver. In 1943 he received the appointment of inspector of the Department of Railways of the Province of B.C. He later worked with the Pacific Great Eastern Railway. In 1948 he accepted his present position as chief mechanical engineer of the Ontario Northland Railway, North Bay, Ont.

W. G. Mitchell, M.E.I.C., chief design engineer, Canadian Bridge Division, Dominion Steel and Coal Corporation Limited, Walkerville, Ontario, has been elected to Council. He will represent the Border Cities Branch.

Mr. Mitchell received the bachelor degree in engineering from Trinity College, Dublin, Ireland in 1925. After several years in the London offices of Dorman Long and Company, he came to Canada in 1929 and joined Canadian Bridge as a draughtsman. Mr. Mitchell was chief draughtsman for the company for a number of years before being appointed to his present position.

He served the Border Cities Branch E.I.C. as chairman in 1956.

J. W. Dolphin, M.E.I.C.

J. W. Millar, M.E.I.C.

W. G. Mitchell, M.E.I.C.

T. H. Newton, M.E.I.C.

J. S. Waddington, M.E.I.C.

R. H. Self, M.E.I.C.

R. Harvey Self, M.E.I.C., will be a councillor representing the Toronto Branch for a three-year term. As comptroller of buildings and plants for the Board of Education of the City of Toronto, he is in charge of the architectural, engineering, and maintenance and custodial work of buildings of the Board, which he joined in 1955.

Mr. Self graduated from the University of Toronto in 1938 with a B.A.Sc. degree in civil engineering. He joined Ontario Hydro in 1940 after two years with various companies. Later, in 1943-1945 he was on loan to the Department of National Defence at Ottawa. In 1951 he was appointed generation construction engineer for the Ontario Hydro. In 1954 he was appointed the rehabilitation engineer for the St. Lawrence Seaway project in charge of the rehabilitation program on the Canadian side.

Mr. Self is the former chairman of the Toronto Branch of the Institute. He has also been a member of committees of the Institute.

J. S. Waddington, M.E.I.C., has been re-elected a councillor of the Institute to represent the Brockville Branch of the Institute. A biography of Mr. Waddington, division manager of Phillips Electrical Company, appeared in the June 1957 issue of *The Engineering Journal.* This was in connection with his first election as councillor.

A. D. Janitsch, M.E.I.C., has been elected a councillor of the Institute representing the Belleville Branch.

Mr. Janitsch is associated with Stephens-Adamson Mfg. Co., of Canada Ltd., Belleville, and is a former sales engineer of the company.

T. N. Davidson, M.E.I.C.

P. W. Gooch, M.E.I.C.

H. Chaput, M.E.I.C.

J. E. Hurtubise, M.E.I.C.

He is a mechanical engineering graduate of McGill, B.Eng., 1940. He worked first for Frost & Wood Co. Ltd., at Smiths Falls, Ont., before going to Belleville in 1942.

C. A. Crawford, JR.E.I.C., will represent the Chalk River Branch on the council of the Institute.

Mr. Crawford is a mechanical engineering graduate of University of British Columbia, B.A.Sc., 1951. He is a design engineer in the research engineering department of Atomic Energy of Canada Limited, Chalk River.

Hector Chaput, M.E.I.C., councillor-elect for the Ottawa Branch of the Institute, is equipment manager, Ottawa Transportation Commission.

He graduated from Queen's University in 1941, with a B.Sc. degree, after which he completed the C.G.E. test course. He served with the R.C.A.F. as a signals officer and pilot.

After service with the English Electric Company as a design engineer, he was appointed to the Ottawa Transportation Commission staff in 1949 as an electrical engineer.

Mr. Chaput is a past chairman of the Ottawa Branch of the Institute.

T. N. Davidson, M.E.I.C., of Montreal has been elected a councillor of the Institute representing the Montreal Branch. He has earlier served the Branch as a member of the executive, program chairman and as a member of various committees.

Mr. Davidson attended Queen's University where he received a B.Sc. degree in electrical engineering in 1941. Upon graduation he became associated with the Canadian National Carbon Company in Toronto, leaving in 1942 to enlist in the R.C.N. where he served as an electrical officer.

He joined Northern Electric Company in Montreal in 1945 and is presently assistant superintendent, plant engineering in the headquarters staff organization of the Company.

P. W. Gooch, M.E.I.C., will be a councillor of the Institute representing the Montreal Branch for a three-year term. Mr. Gooch was educated at Upper Canada College, the University of Toronto, faculty of applied science and engineering.

He graduated in 1936 with a degree of B.A.Sc. and in 1937 obtained the degree of M.A.Sc. His first engineering work was with DeHavilland Aircraft of Canada, after which he worked from 1939 to 1941 with DeHavilland Aircraft Company, Hatfield, England. From 1941 to 1947 he was with Canadian Vickers Ltd., Aircraft division and Canadair Ltd. in various positions. Since 1947 he has been with Canadian Vickers Ltd. industrial division and his present position is chief engineer. Mr. Gooch was chairman of the Montreal Branch of the Institute in 1958. He had served earlier on the Branch executive and as a member of Branch committees. He is also a member

V. Jepsen, M.E.I.C.

A. S. Mitchell, M.E.I.C.

of the Institute's Committee on Education.

Jacques E. Hurtubise, M.E.I.C., will be one of the representatives of the Montreal Branch on the Council of the Institute.

After obtaining a bachelor of arts degree, professor Hurtubise entered Ecole Polytechnique, Montreal where he graduated in 1934. He took a post-graduate course in soil mechanics at the Massachussets Institute of Technology in 1939, and subsequently obtained his M.Sc. degree at Ecole Polytechnique.

He was a member of the teaching staff at Ecole Polytechnique from 1934 to 1937, after which he was employed by consulting engineers. He returned to Ecole Polytechnique in 1939, first as assistant professor and subsequently as associate professor and professor of civil engineering.

Professor Hurtubise has been active as a consultant. Since 1953 he has been acting as a consultant for the St. Lawrence Seaway and the Joint Board of Engineers.

A. S. Mitchell, M.E.I.C., has been elected councillor representing the Eastern Townships Branch of the Institute.

Mr. Mitchell graduated from McGill University in 1938 with honours in metallurgical engineering. He has worked for the International Nickel Company at Copper Cliff and the Consolidated Mining & Smelting Company at Trail and Yellowknife, N.W.T. and in 1941 he joined the Union Screen Plate Company of Canada (Limited) at Lennoxville, Que., as a plating engineer. He is presently works manager of the Lennoxville, Que., plant.

Mr. Mitchell is a former treasurer of the Eastern Townships Branch.

Viggo Jepsen, M.E.I.C., will represent the St. Maurice Valley Branch of the council of the Institute for a two-year term.

Mr. Jepsen joined the staff of the Consolidated Paper Corporation in 1936 in Grand'Mere and remained there until 1955 when he was transferred to the head office in Montreal. He became assistant chief engineer, the position he now holds.

Mr. Jepsen was born and educated in Denmark. He came to Canada in 1928 and was connected with the preliminary investigations for hydro-electric developments of the Upper St. Maurice River and the construction of the Rapide Blanc dam and power house. In 1932 he worked for Jas. A. Ogilvy Ltd., Montreal as sales engineer and early in 1936 he transferred to the Canadian Copper Refiners Ltd. at Montreal East as design engineer.

He is a past councillor of the Institute representing the St. Maurice Valley Branch from 1947 to 1949.

Jean R. Menard, M.E.I.C., of Rimouski, Que., will be a councillor of the Institute representing the Lower St. Lawrence Branch. He is a past chairman and secretary of the Branch.

Mr. Menard is a graduate of Ecole Polytechnique, class of 1943. He was with the Canadian Army, serving overseas with the R.C.E.M.E. during the war. In 1946 he was discharged with the rank of captain.

He joined the Department of Public Works of Canada in the Quebec District. In 1948 he was transferred to Rimouski.

B. M. Monaghan, M.E.I.C., of Seven Islands, Que., is re-elected as councillor representing the North Shore Lower St. Lawrence Branch.

Mr. Monaghan was the first chairman and has been councillor of this Branch since it was inaugurated late in 1958. He is chief engineer of the Quebec North Shore and Labrador Railway.

He graduated from the University of Saskatchewan in civil engineering in 1946. He went to Seven Islands after a few years in surveying for the Department of Mines and Resources. He has been a location engineer for the railway and assistant chief engineer.

A. B. Sinclair, M.E.I.C., superintendent of the hydro-electric department of Price Brothers and Company, Kenogami, Que., has been re-elected a councillor of the Institute representing the Saguenay Branch.

Mr. Sinclair's biography was published in the June 1957 issue of the *Journal*, on the occasion of his earlier election to this office.

S. B. Cassidy, M.E.I.C., communications and electrical contractor will represent the Fredericton Branch on the Council of the Institute for a second term.

A biography of Mr. Cassidy appeared in the June 1957 issue of the *Journal*, on the occasion of his election to this office.

Charles Miller, M.E.I.C., will represent the Baie Comeau Branch on the Council of the Institute.

Mr. Miller is general manager of the Manicouagan Power Company, Baie Comeau, Que.

Graduating from Queen's University in 1930, he worked with the Saguenay Power Company Ltd. at Arvida, Que. He was assistant resident engineer for a project at Shipshaw, and he was chief engineer of Aluminum Power Company Limited in 1944.

In 1945 he went to the Beauharnois Light Heat and Power Co., Beauharnois. He joined the Ontario Paper Company in 1947, working on construction of a development of the Manicouagan Power Company. Later he worked as a consulting engineer in Montreal. He was the project manager of the Canadian British Aluminium Company Development at Baie Comeau, Que. He received his present appointment this year.

Mr. Miller is a former chairman of the Saguenay Branch of the Institute.

J. R. Menard, M.E.I.C.

N. F. Stewart, M.E.I.C.

M. C. Collins, M.E.I.C.

L. L. Spurr, M.E.I.C.

T. C. Higginson, M.E.I.C., president of Eastward Industries Ltd., Saint John, N.B., has been elected to represent the Saint John Branch on the Council of the Institute for the next two years.

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 vice-president of the Saint John Board of Trade.

He was born and educated in Montreal. He joined the Automatic Sprinkler Company of Canada in 1928, becoming 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.

R. D. T. Wickwire, M.E.I.C., will represent the Halifax Branch on the Council of the Institute.

Mr. Wickwire is with the Nova Scotia Power Commission, Halifax. He is a mechanical engineering graduate of Nova Scotia Technical College class of 1946.

He has been serving on the Council of the Institute since last year, after having been active in the affairs of the Institute in Halifax.

Lawrence L. Spurr, M.E.I.C., will be a councillor of the Institute, representing the Amherst Branch.

Mr. Spurr is employed as the outside plant supervisor for the Canadian Broadcasting Corporation at their international shortwave transmitter in Sackville, N.B.

Mr. Spurr is a graduate of Acadia University and of the Nova Scotia Technical College, receiving a degree in civil engineering in 1947. He worked for the Nova Scotia Power Commission as a resident engineer until 1953, when his service with the C.B.C. started.

Norman F. Stewart, M.E.I.C., of the contracting firm, County Construction Co. Ltd., Charlottetown, will be on the council of the Institute, representing the Prince Edward Island Branch.

Mr. Stewart studied at Dalhousie University and at Nova Scotia Technical College, gaining his degree of bachelor of engineering, civil, in 1951.

He had earlier served in the Canadian Army (Active), 1940-1943; and in the R.C.A.F. (air crew) from 1943-1945. He served as a flight engineer, and was discharged with the rank of flying officer.

He is a past chairman of the Charlottetown Branch of the Institute, and a past president of the Association of Professional Engineers of P.E.I.

Marshall C. Collins, M.E.I.C., will represent the Corner Brook Branch on the Council of the Institute.

Mr. Collins attended Clarkson College of Technology at Potsdam, N.Y., graduating in mechanical engineering, B.Sc., 1928.

He went to Central America and worked for some years for the United Fruit Company. Returning, he worked on heavy construction jobs, and he joined International Paper Company in 1935 at the Philadelphia plant of a subsidiary. He transferred in 1936 to a newsprint mill at Corner Brook, Nfld. He remained at this plant when ownership passed to Bowaters Newfoundland Pulp and Paper Mills Ltd. He became assistant chief engineer, 1940, chief engineer, 1948. He is now resident development engineer, responsible for long term planning.

C. H. Conroy, M.E.I.C., will represent the St. John's, Nfld., branch on the Council of the Institute.

Mr. Conroy is chief engineer of the Department of Public Works (Nfld.).

He studied at St. Bonaventure's College, at St. Francis Xavier University, and at Massachusetts Institute of Technology. He received the degree in electrical engineering in 1928.

He worked as an electrical engineer for International Power and Paper Co. Ltd., at Corner Brook and Deer Lake, and in 1934 joined the Department of Public Works.

A. B. Sinclair, M.E.I.C.

Charles Miller, M.E.I.C.

S. B. Cassidy, M.E.I.C.

T. C. Higginson, M.E.I.C.

Personals

G. G. Meyerhof, M.E.I.C. (D.Sc. 1954, civil, London) has accepted an invitation by the Council of the Institution of Structural Engineers, London, England, to become the Institution's representative in Eastern Canada. He is head of the department of civil engineering, Nova Scotia Technical College, Halifax, N.S.

W. L. Wardrop, M.E.I.C. (B.Sc., elec. and civil, Manitoba, 1939, 1947) consulting engineer in Winnipeg has been elected chairman of the Winnipeg Branch of the Institute.

G. N. Martin, M.E.I.C. (B.A.Sc. C.E. Polytechnique 1934) of Dominion Bridge Company Limited has been appointed general Manager, boiler division, for the company with office at Lachine, Que.

W. G. Holt, M.E.I.C. (B.A.Sc., mech, Toronto 1936) has been appointed general manager, mechanical division for the Dominion Bridge Company Limited with office at Lachine, Que.

Thomas Dembie, M.E.I.C. (B.A.Sc., civil Toronto 1936) of Dominion Bridge Company Limited, has been appointed chief engineer in the Toronto plants of the company.

Duncan N. Smith, M.E.I.C. (B.Sc., civil, Indiana) has been appointed chief design engineer in the Toronto plants of Dominion Bridge Company Limited.

Malcolm D. H. Dickson, M.E.I.C. (M.A., civil, Cambridge, 1945) has been made vice president of Newton, Dickson and Associates Limited, Toronto.

Charles J. Ward, M.E.I.C. (B.Sc., ceramic, Saskatchewan, 1936) has been appointed assistant city building inspector for the city of Regina.

Philip T. Nash, M.E.I.C. (B.Sc., mech., Queen's 1945) of Trane Company of Canada Ltd., at Windsor, Ont, has been appointed special projects engineer with the company in Toronto.

John W. Forster, M.E.I.C. (B.Sc., civil, Alberta 1944; M.Sc., Iowa, 1947) has gone to Madison, Wisconsin, to work as a hydroelectric engineer for Hydro Electric Planners.

L. F. Bresolin, M.E.I.C. (B.A.Sc., chem., Toronto, 1950) is process engineer with the Cities Service Refining (Canada) Ltd. Trafalgar refinery, at Burlington, Ont.

Walter A. Byskal, M.E.I.C. (B.Sc., civil, Manitoba, 1953) is a project engineer for Mannix Co. Limited on railroad construction at Chisel Lake, Man.

John C. Robinson, M.E.I.C. (B.Sc., civil, Manitoba, 1956) is assistant regional construction engineer for Central Mortgage and Housing Corporation at Winnipeg.

C. D. McKinney, M.E.I.C. (B.Sc., elec., New Brunswick, 1944) of Shawinigan Water & Power Company has since 1958 worked as superintendent of the Joliette line and substation district, Joliette, Que.

Thomas A. Miller, M.E.I.C. (B.Eng. chem. McGill, 1944) has been transferred from Winnipeg, Man., to Montreal as senior engineer with the Trans Canada Airlines.

Edward N. Reed, M.E.I.C. has been appointed general manager, Parking Authority Of The City Of Ottawa.

Captain B. Yarymowich, M.E.I.C. (B.A.Sc. chem. Toronto, 1949) formerly with the Canadian Army Staff College in Kingston, Ont., has been posted to Montreal as staff captain (administration) at H.Q. Quebec Command.

W. L. Wardrop, M.E.I.C.

G. N. Martin, M.E.I.C.

James C. Leahey, M.E.I.C. (B.Eng. elec., McGill, 1935) is general manager of British Timken (Canada) Ltd., at Toronto, Ont.

H. A. Davis, M.E.I.C. (R.M.C., 1926 B.A., econ., Carleton) is employed in the Department of Finance, Ottawa in the analysis division of the Treasury Board (Defence and Works). He is concerned with construction activities of Departments of National Defence and Public Works.

John C. Robinson, M.E.I.C.

C. D. McKinney, M.E.I.C.

R. T. Bogle, M.E.I.C. (B.A.Sc., mech. British Columbia, 1940) of English Electric Canada has been appointed general manager for the company.

W. T. Bennett, M.E.I.C. (B.S., mech. Tufts, 1924) chief engineer with Canadian International Paper Company, has been appointed vice-president, engineering, for the company.

A. C. Abbott, M.E.I.C. (B.Sc. mech., B.Sc. elec., McGill, 1925, 1926) of The Shawinigan Water and Power Company and

M. D. H. Dickson, M.E.I.C.

Duncan N. Smith, M.E.I.C.

formerly vice-president, distribution, has been appointed vice-president with broader responsibilities in the Company.

W. R. Way, M.E.I.C. (B.Sc., elec., McGill, 1918) of The Shawinigan Water and Power Company, formerly vice-president and chief engineer, has been appointed vice-president with broader responsibilities in the Company's affairs.

Stanley T. Murray, M.E.I.C. (B.A.Sc. chem., Toronto, 1950) was recently appointed town engineer of Aurora, Ont.

Norman J. Allison, M.E.I.C. is assistant division manager with Interprovincial Pipe Line Co., western division, Edmonton, Alta.

Donald R. McLeod, M.E.I.C. (B.Sc. civil, Manitoba, 1947) has accepted the appointment of assistant deputy minister with the B.C. Department of Highways, Victoria, B.C.

Christopher R. MacPhail, M.E.I.C. (B.Sc., civil, Queen's, 1957) has been appointed resident engineer with Isumi, Arnott and Sugiyama, Saskatoon, Sask.

R. T. Bogle, M.E.I.C.

John W. Forster, M.E.I.C.

A. C. Abbott, M.E.I.C.

W. R. Way, M.E.I.C.

Thomas Dembie, M.E.I.C.

G. G. Meyerhof, M.E.I.C.

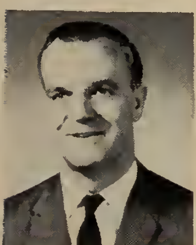
• PERSONALS

Gordon C. Wallace, M.E.I.C. (B.Eng. Liverpool, 1947) has accepted a post as senior design engineer, civil/structural, with Dorr-Oliver Inc., Stamford, Connecticut.

Kurt M. Lissel, M.E.I.C. (B.Sc., civil Saskatchewan, 1950) has been promoted to earth materials section engineer for P.F.R.A. on the South Saskatchewan River Development.

John A. B. Brenan, M.E.I.C. (B.Sc., elec., New Brunswick, 1949) of the New England Telephone and Telegraph Co., Portland, Maine, has been transferred to the company's branch in Boston, Mass.

D. B. Furlong, M.E.I.C. of Producers Pipelines Ltd., Regina, Sask., has been elected president and general manager of the company.



D. B. Furlong,
M.E.I.C.

C. K. Lockwood,
M.E.I.C.

C. K. Lockwood, M.E.I.C. (B.Eng., chem., McGill, 1934) of Shawinigan Chemicals Limited has been appointed vice-president of the new industrial chemicals division.

Mervyn Mindess, JR.E.I.C. (B.Sc., M.Sc., civil, Manitoba, 1955, 1956) has been appointed project engineer with Franki of Canada Ltd., Toronto, Ont.

John S. Howard, JR.E.I.C. (B.Sc., London, England, 1956) is chief projects engineer with John Thompson-Leonard Limited of London, Ontario.

A. Palynchuk, JR.E.I.C. (B.Sc., mech., Saskatchewan 1951) is superintendent of Engineering and Maintenance with Alberta Phoenix Tube & Pipe Limited, at Edmonton.

G. W. Downie, JR.E.I.C. (B.Sc., civil, Alberta, 1946) has been appointed plant superintendent, electrolytic ammonia plant, Warfield, Chemicals and Fertilizers Division of The Consolidated Mining and Smelting Company.

James C. Leahey,
M.E.I.C.

Mervyn Mindness,
JR.E.I.C.

Important "links to"

big savings in lime recovery

• First, an Allis-Chalmers lime sludge kiln recovers lime at approximately half the cost of new lime. Second, the patented chain system for heat recovery in Allis-Chalmers kilns saves up to 40% of fuel costs. Third, the efficiency of this heat recovery system minimizes dust loss to a point that 10% extra capacity can be realized.

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2. Material is lifted into path of hot gases.
3. Flow of gases is directed over sludge bed under suspended chains.

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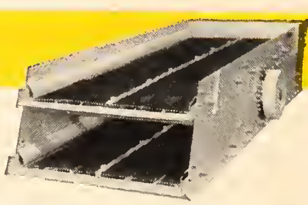

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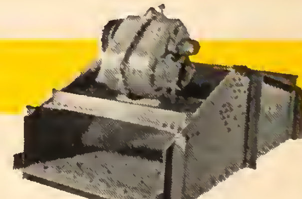

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• PERSONALS

R. B. Walker, JR.E.I.C. (B.Eng., mech. and elec., Queen's, 1949) has been appointed plant manager of the B.A.-Shawinigan Montreal East petrochemical plant.

Jean-Guy Pilon, JR.E.I.C. (B.A.Sc. chem., Polytechnique, 1957) is with Aluminum Company of Canada Ltd., as assistant process engineer, chemical division, at Arvida, Que.

J. A. Morton, JR.E.I.C. (B.Eng. mech., McGill, 1949) has been appointed product manager, insulation department, Atlas Asbestos Company Limited, Montreal.

Donald M. Shook, JR.E.I.C. (B.Sc., civil, Manitoba, 1957) formerly of Vancouver, is employed as assistant erection engineer with Dominion Bridge Company Limited at Calgary.

J. James Chilibeck, JR.E.I.C. (B.Sc., chem., Alberta) of Bird-Archer Co. Limited, has been appointed field engineer with the company in Toronto.

D. W. Hawes, JR.E.I.C. (B.Eng., elec., McGill, 1950) has been appointed chief electrical engineer of Power Corporation Designers & Consultants Ltd., in Montreal.

James M. Warne, JR.E.I.C. (B.Sc., civil, Alberta, 1957) is structural engineer with the Alberta Department of Public Works, Edmonton.

Hugh M. Steeves, JR.E.I.C. (B.Sc., mech., Queen's 1951) with the Kimberly Clark Canada Ltd., Niagara Falls, Ont., is now engineering services superintendent.

Charles R. Baird, JR.E.I.C. (B.Eng., elec., Nova Scotia 1957) is an application-installation engineer with Milltronics Ltd., Peterborough.

George S. Hamilton, JR.E.I.C. (B.Eng., civil, McGill, 1957) is a field engineer with Factory Mutual, Engineering Division, Montreal.

Roland W. J. Boisvert, JR.E.I.C. (B.Eng., civil, McGill, 1953) is project manager with Mitis Construction Co. Ltd., Rimouski, Que.

Jean E. Goulet, JR.E.I.C. (B.Eng., mech., McGill, 1954) has been made sales engineer for the Province of Quebec, with Consolidated Engines & Machinery Company Ltd., Town of Mount Royal, Que.

Lloyd L. S. Larson, JR.E.I.C. (B.Eng., civil, Saskatchewan, 1957) is a junior engineer in the Department of Planning & Works of the City of Ottawa.

Lawrence Mak, JR.E.I.C. (B.Sc., elec., Manitoba, 1957) works as an overhaul research services technician with Trans-Canada Air Lines, Winnipeg.

Jean-Real Lahaye, JR.E.I.C. (B.A.Sc., civil, Laval, 1957) is an assistant engineer with Cartier, Cote & Pietre, Consulting Engineers, Ville LaSalle, Que.

Claude Lemieux, JR.E.I.C. (B.A.Sc., mech. Polytechnique, 1957) is working as a remelt and shipping supervisor with the Beauharnois, Que., works of the Aluminum Company of Canada Limited.

Karl Van Dalen, JR.E.I.C. (B.Sc., civil, Queen's, 1957) is a research student at Imperial College, London, England.

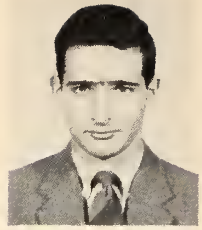
Pierre M. Arsenault, JR.E.I.C. (B.Eng., civil, McGill, 1957) is presently superintendent-engineer with Pointe Claire Asphalt & Construction Inc., Pointe Claire, Que.

Gary N. Hesler, JR.E.I.C. (B.A.Sc., eng. & business, Toronto, 1957) of Square D Company of Canada Ltd., has been transferred to the Ottawa branch as field engineer.

Joseph P. West, JR.E.I.C. (B.A.Sc., mech., British Columbia, 1957) is employed with the British Columbia Power Commission as site mechanical engineer on the Ash River development.

Kenneth M. Johnson, JR.E.I.C. (B.A.Sc., mech., British Columbia, 1957) is flight test engineer with Trans-Canada Air Lines, Dorval.

B. G. Babej, JR.E.I.C.



Malcolm D. Lefcort, JR.E.I.C.

Jean-Jacques Dumas, JR.E.I.C. (B.Sc., elec., Laval, 1957) is an assistant engineer with the Hydro Quebec at Montreal.

Frank R. Jefferson, JR.E.I.C. (B.Eng., chem., N.S.T.C., 1957) is a technical armament officer with the Royal Canadian Air Force in Europe.

Fernand Heroux, JR.E.I.C. (B.Sc., civil, Laval, 1957) is with the City of Shawinigan, Que., as a municipal engineer.

W. Tishinski, JR.E.I.C. (B.Sc., elec., Manitoba 1956) has been working with the Manitoba Power Commission. He is now doing post graduate work at the University of Manitoba.

Marcel Jobin, JR.E.I.C. (B.A.Sc, civil, Laval, 1957) is a project engineer with the Provincial Government at Quebec.

Ernest F. Kaszas, JR.E.I.C. (B.Sc., civil. Alberta, 1957) is a production engineer with Precast Concrete Limited, at Calgary.

Janis Kalnins, JR.E.I.C. (B.A.Sc., mech., British Columbia, 1957) is with the Hydro Electric Power Commission of Ontario as junior engineer.

Roy J. Mutter, JR.E.I.C. (B.Sc., mining, Alberta, 1957) is a technical assistant with the Scottish Council (Development and Industry), at Edinburgh, Scotland.

Jerry A. Hanlon, JR.E.I.C. (B.Eng., civil. Saskatchewan, 1957) is a territorial engineer at Vancouver with the Department of Public Works (Canada), harbours and rivers engineering branch.

Joseph A. F. Lalonde, JR.E.I.C. (B.A.Sc., civil, Polytechnique, 1957) is resident engineer and project engineer with the Lalonde, Girouard & Letendre, Consulting Engineers, Montreal.

Stephen C. Lines, JR.E.I.C. (B.Eng., elec., Saskatchewan, 1957) is stationed at Greenwood, N.S., a navigator in 404 (MP) Squadron, Royal Canadian Air Force.

Joseph Mushka, JR.E.I.C. (B.Eng., mech., McGill, 1957) is a junior engineer, at Canadian Industries Limited, Montreal.

Sidney F. E. May, JR.E.I.C. (B.Sc., civil. Queen's, 1955; M.Sc., Business, Western Ont., 1958) was recently appointed assistant research engineer with the Canadian Pacific Railway Company, at Montreal.

Robert M. McDerment, JR.E.I.C. (B.Sc., civil, Queen's, 1957) is a student at the Osgoode Hall Law School in Toronto.

Algirdas Jurkus, JR.E.I.C. (B.A.Sc., elec., Polytechnique, 1957) is a research student at Sheffield University in England under an Athlone fellowship.

Rene Gagne, JR.E.I.C. (civil, Polytechnique, 1951) former sales engineer for Steel & Timber Structures Ltd., at Quebec City, has been made Manager of a new Montreal branch office.

B. G. Babej, JR.E.I.C. (mech., Hungary, 1953) is working for the Saskatchewan Power Corporation at Saskatoon.

Malcolm D. Lefcort, JR.E.I.C. (B.Eng. mech., McGill, 1956) has been appointed junior research officer in the gas dynamics laboratory, mechanical engineers division, National Research Council.

Arnold C. Floyd, JR.E.I.C. (B.Sc., mech., Saskatchewan) of Honeywell Controls

• PERSONALS

Limited will be responsible for engineering application for the Province of Saskatchewan at the company's Regina office.

L. J. Ingolfsrud, JR.E.I.C. (B.Sc., mech., Queen's 1951; M.Sc., M.I.T. 1952) has joined the nuclear power plant division of Atomic Energy of Canada Ltd., as design engineer.

R. E. Fraser, JR.E.I.C. (B.Eng., elec., N.S.T.C., 1955) is in Chalk River, Ont., an electrical and instrumentation systems design trainee with Atomic Energy of Canada Limited.

Muhammad Abbas, JR.E.I.C. (B.Sc., elec., Punjab, India, 1955) until recently patent examiner at the Canadian Patent Office, Ottawa, is now attending Laval University, Quebec City, where he is studying towards a masters' degree.

Kenneth M. Williams, JR.E.I.C. (B.A.Sc., civil, Toronto, 1956) is a post graduate student in civil engineering, highway engineering option, at the University of Toronto.

Charles R. Simonds, JR.E.I.C. (B.Sc., chem., Queen's 1957) of the 2nd regiment, Royal Canadian Horse Artillery, Winnipeg, has gone to attend a guided missile staff officers course at the U.S. Army Defence School, Fort Bliss, Texas.

Alfred N. Leung, S.E.I.C.

J. James Chilibeck, JR.E.I.C.

J. N. Schilizzi, JR.E.I.C., (mechanical, Paris 1950; London, 1951) project engineer, plant engineering department, at the Aluminum Company of Canada Ltd. Arvida works, is transferred to a post as technical advisor for the Middle East, for L'Aluminium Commercial, Zurich, Switzerland.

Leo I. Rotgaus, JR.E.I.C. (B.Eng., mech., McGill 1956) has joined Winer & Chazonoff Contractors Corp., Montreal, as project engineer.

P. Yachinec, JR.E.I.C. (B.Sc., elec., Alberta 1946) has been appointed general manager for Sinclair Radio Labs Limited, Toronto.

Pierre Thiviere, JR.E.I.C. (B.A.Sc., Polytechnique 1956; M.Sc., thermodynamics, Birmingham, 1958) has joined Canadian Pratt & Whitney Aircraft Company Ltd., Montreal, as an analytical engineer.

R. Marchand, JR.E.I.C. (B.Sc., elec., Manitoba, 1954) is now with the R.C.A.F., Air Materiel Command, engaged in telecommunications maintenance.

B. I. Shulakwych, S.E.I.C. (B.Sc., mech., Manitoba 1957) until recently with Dominion Engineering Company Ltd., Montreal, is doing post graduate work at the University of Toronto in business administration.

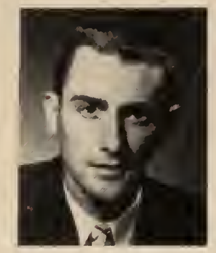
H. K. Beatty, S.E.I.C. (B.Eng., elec., Nova Scotia Technical College 1957) trainee engineer in Canadian General Electric Company Limited, has joined the outside plant engineering department of N. W. Engineering, Downsview, Ont.

R. E. Whitten, S.E.I.C. (B.Eng., civil, Nova Scotia Technical College 1958) is now employed by Foundation Company of Canada, Montreal.

Alfred N. Leung, S.E.I.C. (B.Sc., civil, Manitoba 1958) is doing post graduate studies in highway engineering at the University of Alberta, Edmonton.

K. M. Ferguson, S.E.I.C. (B.Sc. mech., New Brunswick, 1958) is now employed as assistant rubber plant manager with Pirelli Cables, Conduits Ltd., St. Johns, Que.

Alvin W. Kruger, S.E.I.C is a draftsman-computer with Ceepee Oil Co. Ltd., Regina.



A. C. Floyd, JR.E.I.C.

Max Deitch, JR.E.I.C.

• PERSONALS

H. W. Walford, S.E.I.C. (B.Sc., civil, New Brunswick 1958) is doing post-graduate work at the National College for Heating, Ventilating, Refrigeration and Fan Engineering in London, England, under an Athlone Fellowship.

M. P. Paidoussis, S.E.I.C. (B.Eng., mech., McGill 1958) is with General Electric Co. of England, Ltd., Erith, Kent, under a nuclear engineering overseas training fellowship.

F/O David Greenfield, S.E.I.C. (B.A.Sc., civil, Toronto 1958) is at present taking the R.C.A.F. maritime navigation course at Summerside, P.E.I.

James Broughall, S.E.I.C. (B.Sc., chem., Queen's 1958) is a junior chemist with the Canadian International Paper Company, at Gatineau, Que.

Colby Burns, S.E.I.C. (B.Eng., civil, Saskatchewan 1958) is with the City of Regina, Sask., as assistant roadways engineer.

C. R. W. MacPhail, S.E.I.C. (B.Sc., civil, Queen's 1957) has become a field engineer with Izumi, Arnott and Sugiyama, Regina, Sask.

Robert Desrosiers, S.E.I.C. (B.A.Sc., civil, Laval 1957) is with Laminex Products Limited, Quebec, Que.

John H. Morrish, JR.E.I.C. (B.A.Sc., civil, Toronto, 1952) formerly of Montreal has been appointed division engineer with the Canadian Pacific Railways, Schreiber Division, Schreiber, Ont

Max Deitch, JR.E.I.C. (B.Eng. elec., McGill, 1952) has recently been appointed product manager, high tension switchgear, of Canadian Line Materials Ltd., Toronto, Ont.

P. Vink, JR.E.I.C. (B.Sc., civil, London, England 1955) is employed by De Leuw Cather and Company Ltd. in Toronto, as a junior engineer.

Benedict Chan, S.E.I.C. (B.Sc., mech., Manitoba 1957) of Otis Elevator Co., New York, has been appointed an engineer trainee in the executive office of the company.

Clifford H. Laurence, S.E.I.C. was transferred early this year by the Shawinigan Water & Power Company from the production plant department Shawinigan, Que., to the electrical repair department, Three Rivers.

Norman J. Antaya, S.E.I.C. (B.Eng., elec., Detroit 1958) has joined the Saskatchewan Power Corporation, Regina, as assistant distribution engineer.

M. J. Minor, S.E.I.C. (B.Sc., elec., Manitoba 1958) is plant engineer with the Hydro Electric Commission of Ontario, at Seven Sister Falls generating station.

R. D. Thibodeau, S.E.I.C. (B.A.Sc., chem., Toronto 1958) is at Assumption University of Windsor, where he is studying towards a masters degree.

Benoit St. Laurent, S.E.I.C. (B.Sc., civil, Laval 1958) is with the Department of Highways of Quebec.

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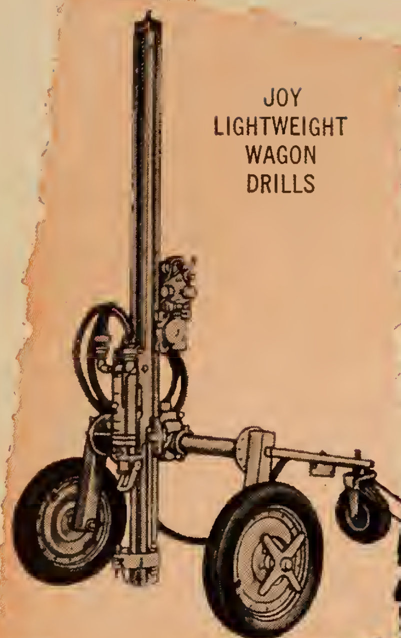


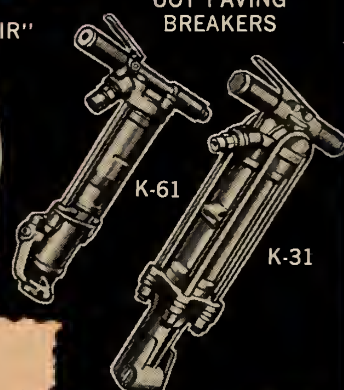
JOY LIGHTWEIGHT WAGON DRILLS

JOY HAND HELD ROCK DRILLS

L-37

L-27

JOY "PISTONAIR" AIR HOISTS



JOY PAVING BREAKERS

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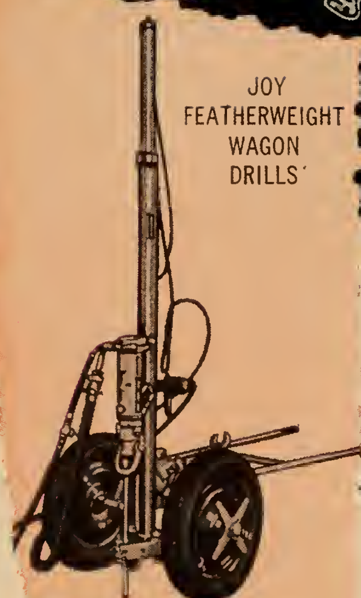
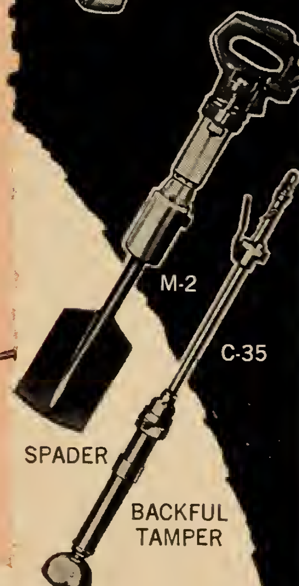
K-31



JOY FEATHERWEIGHT WAGON DRILLS



M-2

C-35

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NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute and abstracts of the papers presented at their meetings

BAIE COMEAU

G. W. Scott, M.E.I.C., *Correspondent*

WINTER NAVIGATION was discussed by Dr. Huet Massue, M.E.I.C. on March 25. Dr. Massue is general manager of the lower St. Lawrence and Gulf Developments Association.

Dr. Massue's observations and analysis gave a clear indication of the enormous industrial developments to be expected along the north shore of the lower St. Lawrence during the next ten years particularly east of the Bersimis River, where the Hydro Electric and mineral resources of this area have yet to be fully exploited. A final conclusion of Dr. Massue's analysis was the necessity for all-year-round navigation in the lower St. Lawrence.

CAPE BRETON

H. M. Aspinall, M.E.I.C., *Correspondent*

RADIO-ISOTOPES—Some of their Industrial Applications was the subject discussed by Frank L. Martin on March 31st, 1959. Mr. Martin is research metallurgist, Dominion Iron & Steel Company.

Mr. Martin discussed the use of radioactive tracers in the study of water flow and gas flow; and in some industries. Some examples were the examination of a sheet metal for a thickness uniformity, study of origin of non-metallic inclusions in steel products.

The great interest of the audience of thirty-five members and guests was demonstrated by the brisk questioning following the talk.

CENTRAL, B.C.

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

DR. K. F. TUPPER was guest at a dinner meeting with Mrs. Tupper and with Dr. and Mrs. Garnet T. Page on March 19. Dr. Tupper talked about the work of the E.I.C. concluding with interesting remarks on his and Dr. Page's visit to Russia. Dr. Tupper was present at the dedication of a memorial plaque in honour of pioneer engineers and especially F. W. Groves who from 1908 until 1948 was primarily responsible for the design and maintenance of irrigation work in the vicinity of Kelowna. This plaque is located on the shores of the Okanagan Lake near the Kelowna Memorial Museum.

CORNER BROOK

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

LABOUR UNIONS were the subject of a paper by F. J. Fitzpatrick on March 12. Mr. Fitzpatrick is solicitor and assistant secretary, Bowaters Newfoundland Pulp & Paper Mills, Ltd. He outlined the legal relationships between employers and unions as well as some of the regulations governing them individually.

Mr. Fitzpatrick thinks it is time for some revisions of our labour legislation perhaps along the lines of the so called "Right to Work" laws of some states in the U.S.A. A long lively question and answer period followed, centring chiefly around the current loggers' labour dispute in Newfoundland.

EDMONTON

I. G. Finlay, M.E.I.C., *Correspondent*

DR. R. E. FOLINSBEE, Head, Department of Geology, University of Alberta gave a talk titled "Our Fuelish Hopes" on February 17. In a general review of the fuel situation in Alberta, Dr. Folinsbee pointed out that new exploration techniques had accounted for a marked increase in reserves of oil and gas in the last ten years. However, these reserves are minute as compared to those in the Middle East and this in conjunction with the ease of production in the Middle East areas make future for the industries in Alberta somewhat cloudy.

The merits of additional pipeline construction would appear to be doubtful under the circumstances he said and in view of the fact that discovery of new oil or gas fields seems to be reaching a maximum with present techniques.

DR. JOHN T. DEUTSCH, Head of the Department of Political Economy of the University of British Columbia, was the speaker on March 13. His subject was the role of the engineer in Canadian development.

E.I.C. PRESIDENT K. F. TUPPER, visited the branch on March 30, when he reviewed the affairs of the Institute and announced the Western Technical Conference to be held in Banff next October. Dr. Tupper told of his impression formed in his travels across Canada of the vast potential of natural resources awaiting development. He was accompanied by general secretary Garnet Page, Mrs. Tupper and Mrs. Page.

Dr. Page presented an E.I.C. prize in engineering to Robert K. Teshima fourth year student in engineering physics at the University of Alberta.

The engineers wives club of Edmonton and the wives of the executive of the Edmonton Branch entertained Mrs. Tupper and Mrs. Page at cocktails and dinner on March 30.

FREDERICTON

Lyle W. Smith, JR.E.I.C., *Correspondent*

ROBERT LYNCH, speaking at a meeting of March 16, pointed out some of the changes which have taken place during his twelve years with the Department of Public Works of New Brunswick highway division. Modern highway practice was being used in New Brunswick. Using a cost comparison, over ten years, Mr. Lynch said that although the cost had gone up considerably the standard of highway has risen even more.

HAMILTON

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

A. E. BERRY, M.E.I.C., General Manager and Chief Engineer of The Ontario Water Commission spoke on February 19, about the program of O.W.R.C. Following a buffet luncheon, Dr. Berry opened his remarks by stating the scope of the commission. The commission though given very wide powers in 1957 is reluctant to use the more extreme powers.

Some of these powers are, action against community if it is not providing satisfactory water service to its consumers, aiding neighbouring municipalities to work jointly to solve mutual problems of water resources and action to prevent pollution of Ontario's waters. The commission will place in use in 1959 its new laboratory.

LAKEHEAD

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

NOEL DANT spoke at the meeting of March 31, on the subject of the direction the future expansion of the Lakehead will take, due to the influence of the Seaway. Mr. Dant is director of the Lakehead planning board. His interesting and informative talk was heard by about forty members of the branch as he outlined some of the problems confronting this area. There are many opinions as to the effect of the seaway, and Mr. Dant feels that a few years of operation are needed before the full potential could be assessed. One opinion is that the first ten years of the seaway will belong to eastern Canada while the second decade of operation will bring major changes to the Lakehead area. A lively discussion period followed Mr. Dant's talk.

LETHBRIDGE

G. G. Campbell, M.E.I.C., *Correspondent*

PLASTICS was the subject discussed on February 20, by Jack Burkell, process engineer supervisor, of C-I-L, Edmonton.

The location of the polythene plant in Edmonton was mainly due to the gas field supply, and the properties of the gas. The main problem in production of polythene is that temperatures are critical, and pressures of 30,000 p.s.i. are required.

MONTREAL, Junior Branch

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

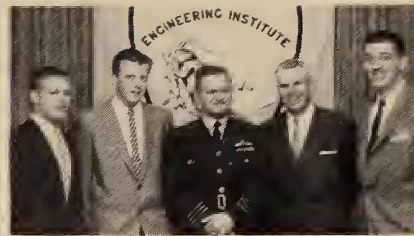
STUDENTS NIGHT was on January 28, with four speakers, two from Ecole Polytechnique and two students from McGill University. A successful turnout of over 100 students was the result. Two of the papers were given in French and two in English, the topics being directly concerned with the students' studies and summer employment.

Five of the Montreal Student Guidance Committee members: Howard Tinkler, Florian Leroux, Herb Moore, Don Young and Jack Hahn.

NIPISSING AND UPPER OTTAWA

D. J. Thornton, S.E.I.C., *Correspondent*

WING COMMANDER HAROLD J. M. LONDEAU spoke at the meeting of March 11 on the subject "The Engineer in the R.C.A.F." The speaker is from R.C.A.F. Headquarters, Ottawa. As in previous years the branch was host to the Grade 13 students from North Bay, Sturgeon Falls and Temiskaming who intend to follow an engineering career. The dinner meeting was attended by about 100 members and their student guests. Wing Commander Londeau discussed the various requirements of an engineer in the Air Force and the fields in which today's engineer might expect to be working in the future. An Air Force film was shown after which there was an informal discussion.



Don Farnsworth, Erlend Skolseg, Speaker Wing Cmdr. H. J. M. Londeau, J. S. Cooper, chairman, and Ron Granger, at meeting of Nipissing and Upper Ottawa Branch.

OTTAWA

D. R. Grimes, JR.E.I.C., *Correspondent*

A SUMMARY OF MEETINGS since January is as follows:

50TH ANNIVERSARY DINNER JANUARY 17. Approximately 170 people attended the dinner celebrating the 50 years of the Ottawa Branch of the Institute. At the Anniversary Dinner greetings to the Branch were given by Hon. Howard Green, Minister of Public Works and His Worship Mayor George Nelms. There were anniversary comments from some senior members of the Branch and greetings to the branch from Dr. K. F. Tupper, President of the Institute. The branch was founded in January 1909 when thirty-five persons attended a meeting which elected Col. W. P. Anderson as chairman. Since that first meeting membership of the branch has climbed to more than 1,000, including some 300 student members.

LUNCHEON MEETING February 5th.

At this meeting Col. W. A. Capelle, M.E.I.C. spoke about the Canadian Army in Gaza. He said Israeli and Arab border incidents have been practically eliminated by the United Nations Emergency Force guarding the Gaza strip. Col. Capelle gave highlights of his recent year's duty with Canada's contribution of 900 men at the UNEF camp at Rafah in the Sinai area.

PAPERS NIGHT—Junior Section,

The Junior Section of the branch arranged Papers Night on February 27, at which seven papers were given and at which three judges had the difficult problem of selecting winners who were as follows:

IN THE JUNIOR SECTION,

First—K. Burn of National Research Council for his paper Techniques of Measuring Moisture Content of Soils by Using Radioactive Materials.

Second—F. Marchand of Marchand Electric Company for his paper "Automatic Controls in Machines".

STUDENTS SECTION

First—J. Therrien of Ottawa University who gave a slide illustrated talk on "Tellorometer".

Second—P. Lemay of Ottawa University who spoke on "Some Aspects of Application of Nuclear Magnetic Resonance".

VISIT TO BUILDING RESEARCH CENTRE February 19. Sixty members took part in a tour of the Building Research Centre National Research Council on February 19. To start the tour R. F. Legget, Director of the Division spoke on the broad field of building research in Canada, stressing that portion of the Division's work which was being carried out in various parts of the country. The tour included visits to laboratories engaged in work on building materials (concrete, masonry and paint), soil mechanics and snow and ice. In addition visits were paid to the acoustics and structures laboratories as well as to laboratories engaged in work on thermal insulation and vapour permeability.

LUNCHEON MEETING, March 5.

Russell Smart, Barrister, Ottawa spoke on Patents of Invention. Patent protection is vital to both inventor and manufacturer said Mr. Smart. Patents form a medium of exchange in industry and result in a freer exchange of technieal knowledge between different members.

PETERBOROUGH

J. G. Hooper, M.E.I.C., *Correspondent*

BUILDING IN THE FAR NORTH OF CANADA was discussed by Robert F. Legget, on March 12, 1959. Dr. Legget is Director of Building Research, National Research Council. His audience numbered one hundred and forty members and guests. If Canadians move into that vast area to mine or drill for oil they will have to learn how to adapt themselves to it Mr. Legget said.

The new site for Aklavik, is an example of a planned northern Canadian settlement. Buildings are constructed on wooden piles. The piles are not driven into the ground; holes are bored by steam, the posts are inserted, and the perma-frost is allowed to freeze around them.

ST. MAURICE VALLEY

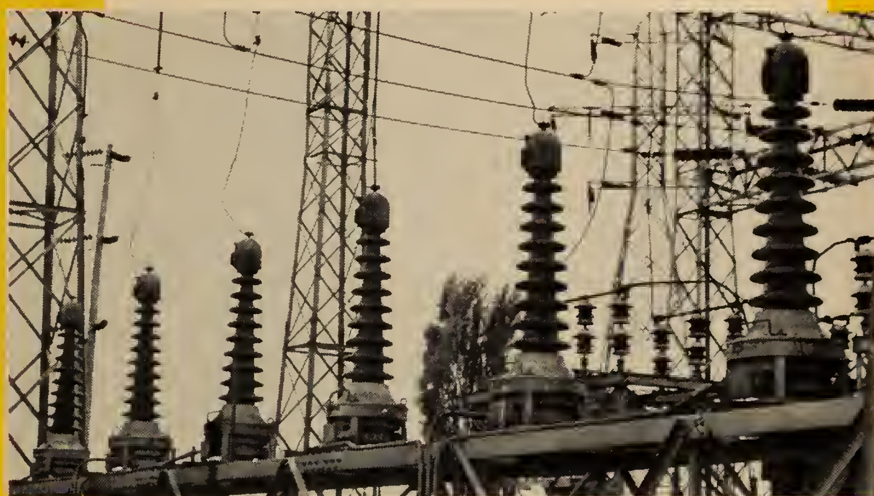
E. A. Love, JR.E.I.C., *Correspondent*

A SUMMARY OF BRANCH MEETINGS is as follows:

SATELLITES. A talk by D. L. Mordell, Dean of Engineering, McGill University, December 2, 1958.

Dean Mordell outlined the possibilities of limited space travel by human beings within the next 15 years and possibly sooner.

HOME BUILDING, some Do's and Dont's, were given by Bert Prime, editor of



"Canadian Builder' on January 15. Mr. Prime's talk dealt primarily with the present trend in house building which he has observed across Canada. Mr. Prime suggested that prospective home builders should investigate the various aspects of home building very closely before they become financially involved and he noted the excellent advice that was available to them from the C.M.H.A. A short question period followed.

DINNER MEETING A visit of the president to the branch was marked on February 26, 1959 with a cocktail party and dinner. Mr. Tupper was accompanied by general secretary Garnet Page.

TORONTO

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

TWO MEETINGS were held by the Toronto Branch, March 5 and March 19 speakers were E. B. Danard, Babcock-Wilcox and Goldie McCullock Limited, Toronto and Dr. Lapp, project engineer, missile division, de Havilland Aircraft of Canada Limited, Downsview, Ont.

Mr. Danard said that the engineer is always searching for better and more efficient ways to accomplish results. In the thermal power field, this may be done by means of increased cycle efficiency. He outlined the advances in steam generation technique ending with an outline of a plant generating at 4500 p.s.i.

Dr. Lapp commented that Canada entered the air age five years after the Wright Brothers flew at Kitty Hawk, but by present indications a longer wait will occur before Canada enters the space age. The speaker showed how space flight is calling on the ingenuity of all engineering disciplines. For example missilry, is one of the activities which generated the systems engineer. Dr. Lapp reviewed the situation with respect to rocket fuels currently used, possible future trends, and the exotic fuels still on the horizon.

CORRECTION. In a report of the Branch annual meeting, March issue, page 108, attendance was given as 32, whereas the correct attendance figure was 324.

VANCOUVER

J. J. Kaller, M.E.I.C., *Correspondent*

GORDON W. SPRATT, M.E.I.C., operations manager with MacDonald & MacDonald Ltd., inspecting and testing engineers spoke on Concrete Admixtures on January 22. Admixtures are used in producing concrete in difficult or specific conditions. In Vancouver less than 20% of total production of concrete is without admixtures. Properties of these chemicals were given and results to be expected from using particular admixtures were described.

PROFESSIONAL DEVELOPMENT COURSE

The Program is as follows: February 4—Principles of Management, February 11—Business Forecasts and Planning, February 18—Organization Problems, February 25—Industrial Engineering—Tools and Applications, March 4—Business Accounting and Finance, March 11—Corporate Investment Policy, March 18—Management and Labour, March 25—Management Consulting.

YUKON

E. W. King, M.E.I.C., *Correspondent*

SPECIAL GUEST at the meeting of March 26, 1959 was Dr. Kenneth F. Tupper president of the Engineering Institute, who spoke in detail of the international affiliations of the E.I.C. He also spoke in some detail of the trip to Russia taken by himself and Dr. Page in late 1958.

This was a dinner meeting with approximately 70 present. At the conclusion of the meeting a film was shown which demonstrates reconnaissance of the road from Dawson City to Fort McPherson which was carried out in 1958 by Federal Department of Public Works engineers.

LIBRARY NOTES

ADDITIONS TO THE INSTITUTE LIBRARY • REVIEWS • BOOK NOTES • STANDARDS

BOOK 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.

THE CHEMICAL KINETICS OF ENZYME REACTION

A general account of the subject, bringing together some of the main results and concepts developed on the physical side. The first eight chapters deal with general principles, basic kinetic laws, mechanisms, hydrostatic pressure etc. The remaining chapters cover individual enzyme systems. The book will be primarily of interest to those in the biological and physical sciences. The author is Professor of Chemistry at the University of Ottawa. (K. J. Laidler. Toronto, Oxford, 1958. 419p., $9.00.)

AN INTRODUCTION TO FLUID DYNAMICS

Intended primarily for students in mathematics and theoretical physics, this volume concentrates on fundamental dynamical principles and their applications to fluid flow. The topics covered include the theory and properties of the perfect fluid, Bernoulli's theorem, irrotational flow, velocity potential, forces on a body in a uniform stream, discontinuous flow, design of wing profiles, slender-body theory, etc. (G. Temple. Toronto, Oxford, 1958. 195p., $3.75.)

ELECTRONIC AVIGATION ENGINEERING

Avigation is "the science or art of conducting aircraft in flight from one point to another". Electronic avigation engineering covers radio and electronic aids to aviation. The systems are grouped in four classes, according to use in long-distance flights, short flights, approach and landing zone, and the airport zone. The equipment described includes: direction finders, consol, navaglobe-navarho, decca, delrac, radux, loran, radar, inertial systems, distance measurement, tacan, fixed-beam and radar low-approach systems, ground magnetic loops, etc. Many references are included for further reading. (P.C. Sandretto. New York, International Telephone and Telegraph Corp., 1958. 722p., $9.50.)

***ELECTRIC LIFTS, 4TH ED.**

Various aspects of design and installation of elevators are covered, including drives, roping systems, motors, variable voltage equipment, brakes, gearing, cars and guides, gates and doors, floor leveling, and control systems. In this edition new illustrations are given for more recent equipment and the text has been rewritten to conform with recent practice. (R. S. Phillips. Toronto, Pitman, 1958. 411p., 63/-.)

***SOLID PROPELLANT ROCKETS; AN INTRODUCTORY HANDBOOK: SECOND STAGE**

This second edition contains additional chapters covering new developments and recently declassified information, including new applications, propellant technology, hybrid rockets, and safety. A particular feature of the volume is the extensive bibliography of over 800 items dealing with solid propellants. (A. J. Zaehringer. Wyandotte, Mich., American Rocket Co., 1958. 306p., $8.00.)

THE PHYSICAL CHEMISTRY OF STEELMAKING

The proceedings of a conference held at M.I.T. in 1956, summarizing present knowledge in the field, and including the results of recent fundamental research and its application to current problems. The subjects covered at the sessions were: liquid metals and properties of solutes in liquid iron and steel; equilibria of reactions in liquid iron and steel; behaviour of metal oxides and of components of iron and steelmaking slags; slag-metal equilibria in blast-furnace and steel-making furnace systems; kinetics and slag-metal reactions; reaction rates in iron and steelmaking processes; solidification of castings and ingots. (J. F. Elliott, ed. New York, Wiley, 1958. 257p., $15.00.)

***FUNDAMENTALS OF ADVANCED MISSILES**

Gives the basic principles determining the performance of guided missiles, ballistic missiles, and space vehicles. Discussed are kinematics of flight, application of fluid mechanics to aerodynamics and propulsion, dynamics, properties of microwaves, application of infrared radiation, radar, guidance, and guided-missile systems. Information is presented from the point of view of theory, experimentation, and typical examples encountered in practice, rather than detailed design of missile types. (R. B. Dow. New York, Wiley, 1958. 567p., $11.75.)

***INDUSTRIAL HYGIENE AND TOXICOLOGY, VOL. 1: GENERAL PRINCIPLES, 2ND ED.**

An extensive treatise on industrial health. Revisions in this volume cover such areas as noise and its environmental implications, heat and its control, ionizing radiation exposures and the inhalation and ingestion of radioactive gases and aerosols, human engineering and industrial safety, industrial sanitation, air pollution, and illumination. (F. A. Patty, ed. New York, Interscience, 1958. 830p., $17.50.)

EDITORIAL NOTES FROM CONCRETE AND CONSTRUCTIONAL ENGINEERING

The main purpose behind these essays is to encourage engineers and scientists to explore beyond technical problems, and to point out the pitfalls besetting those who have not developed an inquiring and logical mind. The essays are concerned particularly with civil and structural engineering, but can be read with profit by most engineers. (H. L. Childe. London, Concrete Publications, 1958. 83p., $1.75.)

***REINFORCED CONCRETE FUNDAMENTALS**

Emphasis is placed on the physical behaviour of reinforced concrete members and the approved ultimate strength theory. Included are enough details of ultimate strength design for practical use, information on the American Concrete Institute Building Code requirements, and a comparison between ultimate strength and working stress analysis. Additional features of the book are a thorough treatment of slabs, working stress methods in detail, and an emphasis on anchorage length as well as moment in its coverage of bend points for steel. (P.M. Ferguson. New York, Wiley, 1958. 604p., $11.50.)

OUR FOREST HERITAGE

The first part of this interesting book is the story of the development of forestry and recreation in New Hamshire, where an intelligent conservation programme has been pursued for the last sixty years. The author's personal reminiscences in the second part cover woods operations in New Hampshire and Canada in the early part of this century. (W. R. Brown. Concord, New Hampshire Historical Society, 1958. 341p., $5.00.)

***NATURAL AERODYNAMICS**

A study of the physical principles and processes of fluid motion. Topics discussed include vorticity, viscosity, boundary layers, wakes and turbulence, buoyant convection, plumes and jets, air waves, and clouds and fallouts. Much of the material contained is of interest to the person working with air pollution problems. (R. S. Scorer. New York, Pergamon, 1958. 312p., $9.00.)

°LINEAR PROGRAMMING AND ASSOCIATED TECHNIQUES

A bibliography containing over one thousand items up to the year 1957. Particular emphasis is placed on applied fields such as production scheduling and inventory control, while certain parallel fields as game theory and linear inequalities are somewhat restricted. Abstracts or annotations are given for most of the items listed. (Vera Riley and S. I. Gass. Baltimore, Johns Hopkins University, for Operations Research Office, 1958. 613p., $6.00.)

°COATED ABRASIVES—MODERN TOOL OF INDUSTRY

Describes how abrasives are manufactured and the various factors involved in their effective use in the metalworking, woodworking, glass and plastics industries, and in applications ranging from heavy material removal to fine polishing. Many recent advances are covered including new automatic machinery and various applications such as strip scouring, pre-plate finishing, and contour finishing. (Coated Abrasives Manufacturer's Institute. Toronto, McGraw-Hill, 1958. 426 p., $9.80.)

°DESIGN AND CONSTRUCTION OF ASPHALT PAVEMENTS

Discusses such aspects as types of asphalt pavements, petroleum asphalts, mineral aggregates, design and construction of hot-mix asphaltic concrete pavements, asphalt pavements and bases employing liquid asphalts, surface treatment and seal coats, and reconstruction of old pavements. A feature of the volume is the appendix on laboratory-mix design of asphaltic concrete. (J. Rogers Martin and H. A. Wallace. Toronto, McGraw-Hill, 1958. 305p., $13.25.)

°ENGINEERING VIBRATIONS, WITH APPLICATIONS TO STRUCTURES AND MACHINERY

Introduction to the analysis of technical vibrations of linear and nonlinear systems with particular emphasis on the transient state of motion. Classical analytical methods are used where feasible as are approximate methods, including the phase-plane graphical method for the solution of transient problems and the Ritz averaging method for solving steady state nonlinear problems. Attention is given to the physical aspects of vibration problems, and nonlinear relationships are introduced where possible. (L.S. Jacobsen and R. S. Ayre. Toronto, McGraw-Hill, 1958. 564p., $12.00.)

°GLASS ENGINEERING HANDBOOK, 2ND ED.

A handbook on the composition, manufacture, properties, and applications of glass as an engineering material. In addition to coverage of the more commonly known glasses, there is information on photo-sensitive glass, glass-ceramics, electrically conducting glass, glass in electronic circuit components, and glass-reinforced plastics. Specific aspects given treatment are stress testing and strength determination, radiation conductivity emissivity, and high energy radiation effects. An extensive section is devoted to fibrous glass. (E. B. Shand. Toronto, McGraw-Hill, 1958. 484p., $12.00.)

°NONLINEAR PROBLEMS IN RANDOM THEORY

In the first comprehensive study of the application of random theory to nonlinear processes, a top-rank mathematical analyst examines the role of nonlinear processes in physics, mathematics, electrical engineering, physiology, and communication theory. He demonstrates how random processes — in space as well as in time — enter into the study of statistical mechanisms, a useful approach to new research in gas and plasma theory, for instance. (N. Wiener. New York, Wiley, 1958. 131p., $4.50.)

°ELEMENTARY MATHEMATICAL PROGRAMMING

Intended as an intermediate approach, the subject is presented in relatively nonmathematical terms. Following a general treatment of the distribution, simplex, and approximation methods, the complete solution and analysis of two typical industrial problems is presented: a manufacturing and a blending problem. The applicability of high-speed computers for solving problems is then discussed, and available computer programs are indicated which will accomplish the solution of mathematical programming problems. The remainder of the book illustrates the details of various problems solved by programming. (R. W. Metzger. New York, Wiley, 1958. 246p., $5.95.)

°ESTIMATING CONSTRUCTION COSTS, 2ND ED.

A practical text outlining various methods of preparing estimates. This edition has been expanded to include more information on bonds, insurance, and depreciation of equipment, as well as new information on stone masonry, house carpentry, interior finish, millwork, wallboard, lathing, plastering, painting, glass, glazing, roofing, plumbing, and electrical wiring. Costs data has been brought up to date throughout. (R. L. Peurifoy. Toronto, McGraw-Hill, 1958. 446p., $11.20.)

FBI REGISTER OF BRITISH MANUFACTURES, 1959

The classified Buyers' Guide lists the products and services of over 7,500 members of the Federation of British Industries under some 5,400 headings. Other sections give the addresses of companies, trade associations, trade marks, and proprietary names. (F.B.I. London, Iliffe, 1959. 1139p., 42/-.)

ASRE AIR CONDITIONING-REFRIGERATING DATA BOOK. VOL. 1: REFRIGERATION APPLICATIONS

The first of a projected four volume series of Data Books to be issued during the next three years, to cover all phases of the industry. This volume deals with the use of refrigeration in the storage, processing, handling and distribution of foods and beverages; low temperature applications in the fields of medicine, metallurgy and cryogenics; industrial applications including ice manufacture, skating rinks, concrete dams, foundations, liquid cooling and photography; refrigeration piping systems.

These volumes grow out of the ASRE Applications and Design Data Books. and they will be revised in rotation. (P. B. Christensen, ed. New York, American Society of Refrigerating Engineers, 1958. irreg. paging, $12.00.)

°GROWTH AND PERFECTION OF CRYSTALS

Reports of an international conference held at Cooperstown, New York in 1958, on crystal phenomena, polymer crystallization, and crystallization of simpler molecules. Organic, inorganic, and polymeric substances are investigated from the standpoint of crystal perfection, formation and structure of whiskers, presence of dislocations, and the mechanism of crystal growth from the melt, solution, and vapor. Several papers emphasize the differences and similarities between polymer and ordinary crystallization. A special feature is the bringing together of literature on whisker phenomena dating back to 1574. (Ed. by R. H. Doremus and others. New York, Wiley, 1958. 609p. $12.50.)

°MAGNETIC AMPLIFIERS: THEORY AND APPLICATION

The fundamentals of magnetism, electromagnetism, and electromagnetic induction are discussed in the preliminary chapters. This is followed by a description of the theory, operation, and application of saturable reactors and magnetic amplifiers in both feedback and non-feedback cases. Present commercial and industrial uses are presented in detail as are the advantages and disadvantages of the magnetic amplifier. (S. Platt. Englewood Cliffs, N.J.. Prentice-Hall, 1958. 238p., $7.00.)

°FUNDAMENTALS OF DIGITAL COMPUTERS

Following a discussion of fundamentals the author explains computer arithmetic applications, binary counting, and special codes; computer circuitry, including the various gates and the circuitry utilizing them, various storage systems found in modern computers; computer programming, including specific examples of programming applied to commercial units; comprehensive descriptions of representative commercial computers. A concluding section deals with servicing and maintenance factors. (M. Mandl. Englewood Cliffs, N.J., Prentice-Hall, 1958. 297p., $9.00.) *(Continued on Page 184)*

E.I.C. CERTIFICATE OF ADVERTISING MERIT

The fifty members of the Institute who were asked to judge — from the viewpoints of ACCURACY — INFORMATION — ATTRACTION — the advertisements in the February issue of the *Journal*, voted strongly in favour of the four-colour insert advertising cable manufactured by the Canada Wire and Cable Company Limited.

Each month, fifty members are being asked to scrutinize the current issue of the *Journal* and to select the advertisement which they consider to have outstanding merit. This method of judging the advertisements is part of a continuous effort to improve the content of *THE ENGINEERING JOURNAL* and to assist the advertisers in presenting their advertising messages in a manner pleasing to the readers.

The advertisement in the February issue which received the second highest number of votes was a double page spread (on pages 12 and 13) released by General Electric Company Limited of England. This advertisement is headed "The Power of Johannesburg".

Front

Back

Winning Canada Wire and Cable Company Insert

This four-colour insert appeared on pages 97 and 98 of the February 1959 issue. It was voted best in the issue—from the viewpoints of ACCURACY — INFORMATION — ATTRACTION — by a large majority of the jury made up of fifty members of the Institute. The advertisement was prepared by Walsh Advertising Company Limited, Toronto.

• BRIEFS

New African Companies — The incorporation of two new companies, Ghana Aluminium Products Limited and Nigeria Aluminium Products Limited is announced by Aluminium Limited of Canada.

Saltbath Furnace — Canadian General Electric announces that the new Ajax submerged-electrode saltbath furnace was to be demonstrated at the National Industrial Production Show of Canada, Toronto, May 4-8.

C-I-L Today — This was the name of the film which was the feature of the annual staff functions of the company in Montreal and Toronto last January; the theme: "Time for testing our competence." Members of staff had the opportunity of meeting the new president, Peter C. Allen.

New Catalogue — Now available from Air Reduction Canada Limited and dealers from coast to coast is a fully illustrated 60 page "General Welding, Cutting and Accessories Catalogue." Copies available from the company, 905 Hodge Street, Montreal 9.

Brick Floors — A 4-page bulletin—"The Embeco Method for Setting Floor Brick", published by The Master Builders Company, Ltd. describes brick floor installation with corrosion-resistant and wear-resistant joints. For free copy write for Bulletin E-27B, The Master Builders Company, Ltd., Toronto 9, Ont.

ASEA Journal — Volume 31, 1958 features an article about a stacker crane with a lifting height of 21 ft., capacity of 2 tons. It has proved to be invaluable in the handling of goods in stores and warehouses.

• LIBRARY NOTES

(Continued from page 149)

°OPERATIONS RESEARCH FOR INDUSTRIAL MANAGEMENT

Presents recently developed operations research techniques used for executive decision making with emphasis on simulation studies. The application of operations research methods is considered in relation to financial allocation, transportation problems, inventory control and production setups. Descriptions are also given for game theory, linear programming, flow techniques, and matrix algebra. The use of electronic computers in relation to operations research is discussed. (D. N. Chorafas. New York, Reinhold, 1958. 303p., $8.75.)

°BOILING WATER REACTORS

A brief history is given of the boiling water reactor concept and of the early experiments at Argonne, including the development and operation of the Experimental Boiling Water Reactor. The various Borax experiments are then described in detail as is the General Electric Company's Vallecitos plant. In addition a thorough explanation is given of the physics underlying the design of the various reactor plants. The book concludes with a discussion of present and future research and development programes on boiling reactors. A volume in the Atoms for Peace presentation set. (A. W. Kramer. Reading, Addison-Wesley, 1958. 563p., $8.50.)

°FLUID FUEL REACTORS

Three basic types of fluid fuel reactors are studied. The first is the aqueous homegeneous reactor. Such factors as nuclear characteristics, properties of aqueous fuel solutions, technology of aqueous suspensions, chemical processing, and design and construction are treated. The second is the molten-salt reactor, with consideration of the chemical aspects, construction materials, nuclear aspects, and heat-transfer systems. The last type presented is the liquid-metal fuel reactor with treatment of such factors as reactor physics, composition and properties of liquid-metal fuels, construction materials, chemical processing, and engineering design. A volume in the Atoms for Peace presentation set. (Ed. by J. A. Lane and others. Reading, Addison-Wesley, 1958. 979p., $11.50.)

°PHYSICAL METALLURGY OF URANIUM

A comprehensive treatment that studies uranium in terms of fundamental properties and mechanisms. Among those aspects studied are radioactivity and nuclear reactions, crystallography, physical and chemical properties, mechanical properties, deformation, recrystallization and grain growth, transformations, diffusion in uranium systems, radiation damage to uranium, thermal-cycling growth, and metallography. An appendix provides phase diagrams for binary uranium alloy systems. A volume in the Atoms for Peace presentation set. (A. N. Holden. Reading, Addison-Wesley, 1958. 262p., $5.75.)

°PROJECT SHERWOOD: THE U.S. PROGRAM IN CONTROLLED FUSION

This is 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 volume in the Atoms for Peace presentation set. (A. S. Bishop. Reading, Addison-Wesley, 1958. 216p., $5.75.)

RADIATION BIOLOGY AND MEDICINE; SELECTED REVIEWS IN THE LIFE SCIENCES

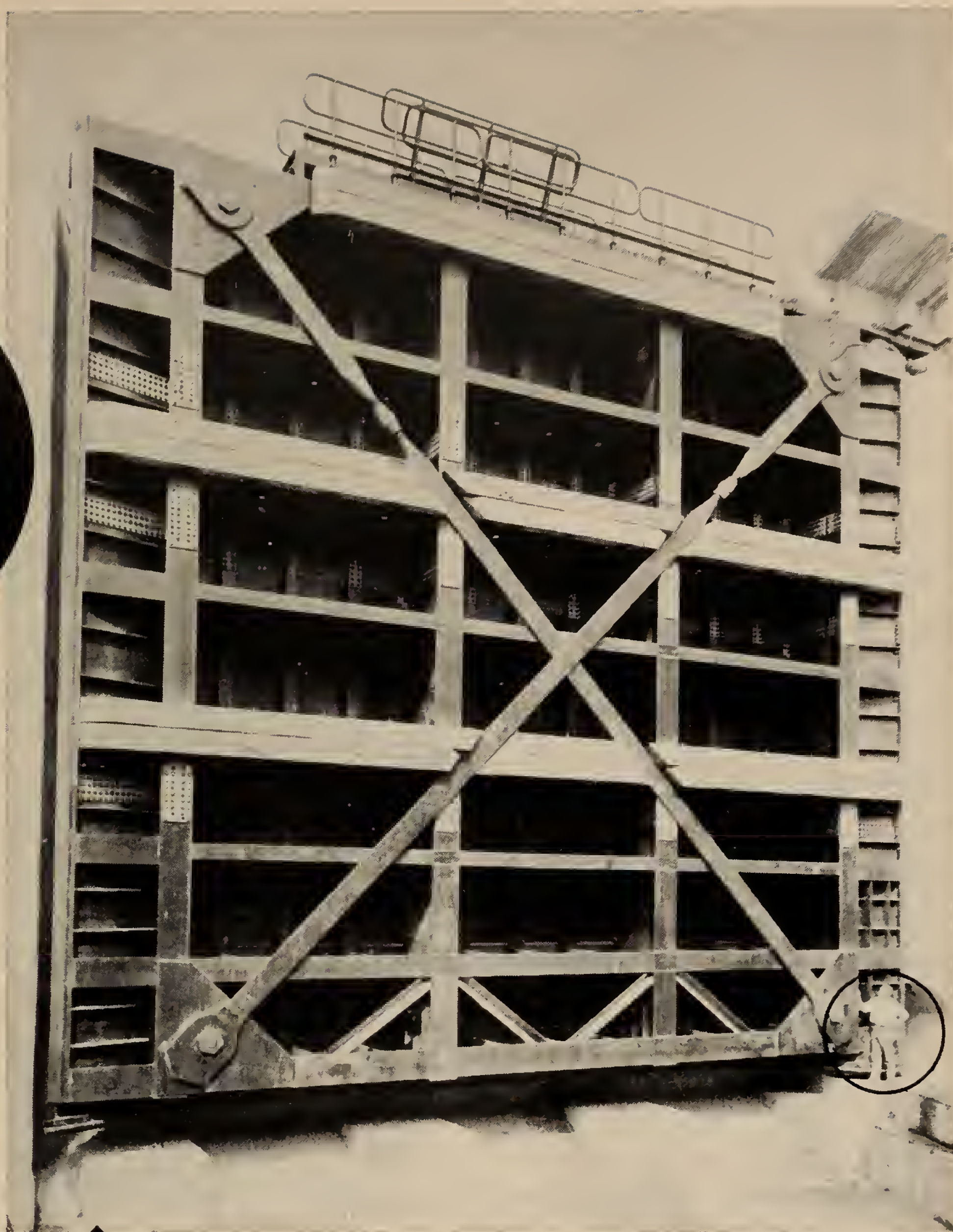
An introductory chapter summarizes the history of the use of radiation in diagnosis, therapy and experimental biology, and discusses the impact of the atomic age on growth and aging, ecology, etc. The next group of chapters deals with the effect of radiation on cells and organs, mutations, mathematical biology, and the effect of radiation on mammals. Four chapters deal with radiation safety. The remaining fourteen chapters are concerned with the uses of radiation, including radioisotopes in medicine and agriculture, accelerators in medical research, tracer applications and radiobiological dosimetry. The volume is concerned with work in the U.S., and is a volume in the Atoms for Peace presentation set. (W. D. Claus, ed. Reading, Addison-Wesley, 1958. 944p., $11.50.)

°THE SHIPPINGPORT PRESSURIZED WATER REACTOR

All aspects of the design and construction of the Shippingport reactor are discussed. Among the topics included are the factors entering into the selection of plant design parameters; reactor design, fuel element development, and core construction; radioactive waste disposal system; electrical and mechanical components used in the reactor plant; shieldings of the reactor plant and waste disposal facilities; hazards evaluation; a description of the turbine-generator plant; training of personnel. A volume in the Atoms for Peace presentation set. (U.S. Atomic Energy Comm., Division of Reactor Development, Naval Reactors Branch. Reading, Addison-Wesley, 1958. 588p., $9.50.)

Canadian Vickers Limited, Montreal, have supplied 12 Upper Mitre Gates and 14 Lower Mitre Gates for St. Lawrence Seaway Locks, in which all joints were field assembled with Stelco High-Strength Bolts, using a total of about 170,000 pieces, ¾" and ⅞" diameter.

Illustrated here is a 110-ton Upper Mitre Gate in the St. Lambert Lock.



Seaway Lock Gates field assembled with STELCO HIGH-STRENGTH BOLTS

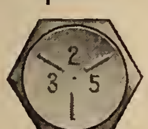
This unusual application for high-strength bolts offers striking evidence of the versatility of this technique in the field fastening of joints in all types of structural steel assemblies.

Stelco High-Strength Bolts require only one third the installation time of rivets. They also provide greater strength both in tension and in shear, are easy to remove for structural alterations, and are re-usable if desired.

High-strength bolting permits favourable working conditions in the field, with a minimum of equipment. A bolting team normally comprises two men, but if necessary the bolts can be installed satisfactorily by one man working alone.

For complete information, contact any Stelco Sales Office. A free technical manual is yours on request.

Every bolt head marked . . . every shipment certified.



All Stelco High-Strength Bolts are guaranteed to conform to ASTM Specification A-325. A certificate to this effect is issued with each shipment and every bolt is identified as shown.

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NATIONAL DIRECTORY OF THE CANADIAN PULP AND PAPER INDUSTRIES, 1958-59.

In this edition, the statistical reviews of the industry have been brought up to date; the mill listings section is arranged by province from west to east, instead of alphabetically. The directory also includes a classified list of manufacturers, lists of paper and pulp mills classified by product, Canadian organizations in the industry, government departments, etc. (J. N. Stephenson, ed. Gardenvale, National Business Publications, 1958. 518p., $5.00.)

°CHAMBER'S TECHNICAL DICTIONARY 3RD ED.

A new edition of a standard reference work encompassing the fields of science, engineering and manufacturing. New terms have been added, while older terms have been revised where necessary to include new aspects. (Ed. by C. F. Tweney and L. E. C. Hughes. Galt, Brett-MacMillan, 1958. 1028p., $7.50.)

°SODIUM GRAPHITE REACTORS

Placing emphasis on the Sodium Reactor Experiment (SRE), such aspects are covered as the reactor and its shielding, cooling, and fuel-handling systems; nuclear, heat-transfer, and transient characteristics; design and development of components; installation of equipment and operation of the plant. In addition information of a general nature is included dealing with the origin of the sodium graphite concept, the technologies of sodium, graphite, and zirconium as they relate to sodium graphite reactor design, and fuel element development. A volume in the Atoms for Peace presentation set. (C. Starr and R. W. Dickinson. Reading, Addison-Wesley, 1958. 288p., $6.50.)

°SOLID FUEL REACTORS

Reviews the basic concepts, present status of development in the United States, and the technical outlook for five projected solid fuel nuclear power reactor types. These are the fast-neutron power breeders, heavy water reactors, gas-cooled reactors, organic moderated and cooled reactors, and a thermal reactor for recycling plutonium. The information presented ranges from well-established experimental, theoretical, and developmental results to analyses intended to provide direction for future work. A volume in the Atoms for Peace presentation set. (J. R. Dietrich and W. H. Zinn, eds. Reading, Addison-Wesley, 1958. 844p., $10.75.)

°THORIUM PRODUCTION TECHNOLOGY

The entire process of thorium production is studied, beginning with the extraction of thorium from ores to the fabricated thorium slug ready for cladding, prior to use in the reactor. Emphasis is placed on the separation of thorium from impurities, its reduction to metallic form, and fabrication of the metal. In addition sections are included on physical and chemical properties of thorium, health and safety aspects of thorium production, and analytical and metallurgical testing procedures. A volume in the Atoms for Peace presentation set. (F. L. Cuthbert. Reading, Addison-Wesley, 1958. 303p., $6.50.)

THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: K. F. Tupper, M.E.I.C. — Treasurer: T. W. Eadie, M.E.I.C. — General Secretary: Garnet T. Page, M.E.I.C

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JUNE 1959

vol. 42 no. 6

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

MEMBERSHIP

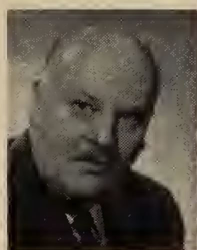
Indexed in
The Engineering Index
The Applied Science and Technology Index
The Canadian Business Index.

(20,350 copies of this issue printed)

MEET THE AUTHORS

L. G. Brazier, PH.D., B.SC., M.I.E.E., director of Research and Education, and director of British Insulated Callender's Cables Limited *(Capacitor Developments in Great Britain).*

Dr. Brazier was educated at London University, served as pilot in Royal Flying Corps and R.A.F. during the war, 1917 to 1919. From 1923-1925 he did mathematical research at Royal Aircraft Establishment on aircraft structures and elastic stability. In 1925 joined Callender's Cable & Construction Company Limited and after their amalgamation with British Insulated Cables Limited was appointed manager (Research). In 1950 he was appointed director of the company, and became director of Research and Education in 1954.



P. A. Sporing, O.B.E., M.SC., managing director of Telegraph Condenser Company Limited *(Capacitor Developments in Great Britain).*

Mr. Sporing was educated in London and Zurich Universities and in 1923 joined the Telegraph Condenser Company Limited of which he became managing director in 1938. He is Director of Telegraph Condenser Company (Canada) Limited and Chairman of British Dielectric Research Limited. Mr. Sporing is the author of numerous patents relating to capacitors.

J. B. Birks, B.A., PH.D., reader in physics, Manchester University *(Capacitor Developments in Great Britain).*

Dr. Birks was educated at Wallasey Grammar School and Queen's College, Oxford. He worked from 1940-45 with Telecommunications Research Establishment and then successively held positions on the faculties of the University of Glasgow, Rhodes University, Grahamstown, South Africa and Manchester University.

Gerald Nadler, assistant professor of industrial engineering, Washington University, Saint Louis, Mo. *(Measuring Human Motions for Designing Machines.)*

Professor Nadler attended the University of Cincinnati and received his B.S.M.E. from Purdue University in 1945, his M.S.I.E. in 1946, and his Ph.D. in 1949. Since 1947 Professor Nadler has taught industrial engineering at Purdue and Washington Universities and also is available as a consulting industrial engineer. He belongs to a number of engineering societies in the United States and is registered with the professional engineers of the State of Missouri.

Jay Goldman, assistant professor of industrial engineering, Washington University, Saint Louis, Mo. *(Measuring Human Motions for Designing Machines.)*

Dr. Goldman attended Duke University where he obtained his B.S.M.E. in 1950, Michigan State University, M.S.M.E. in 1951, and Washington University, D.Sc. in 1955. Dr. Goldman has been teaching industrial engineering at Washington University since 1956 and is also a consultant industrial engineer. Among other societies Dr. Goldman is a member of the American Institute of Industrial Engineers.

R. M. Bremner, P.ENG., A.M.I.C.E., in charge of construction and planning at the University of Toronto. *(3,500 Ton University of Toronto Building Moved 250 Ft.)*

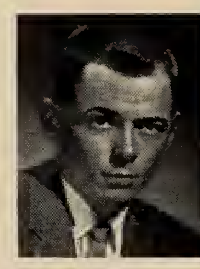
Mr. Bremner graduated from the Royal College of Science & Technology in Glasgow. While in Scotland he was involved in the design and construction of many heavy industrial schemes.

Mr. Bremner came to Canada in 1954. He was responsible for the supervision and design of the foundations and ancillary work for the first civilian sub-critical reactor in Canada.

He is a member of the Association of Professional Engineers of Ontario and of the Institution of Civil Engineers.

Jules O'Shea, JR.E.I.C., Canadair Services Ltd., Pilotless Aircraft Division, Boeing Airplane Co., Seattle, Washington. *(A Typewritten Grammatical Word Counter).*

Mr. O'Shea graduated from the Ecole Polytechnique in 1957 with a B.A. Sc. in electricity and mechanics. He has worked with the control group of the missile system section of Canadair Ltd. to adapt the Sparrow II to the Arrow interceptor. Mr. O'Shea's speech at the Annual Students' Night in Montreal about his electronic device, which he built as a hobby, won him first prize.



Robert J. McTavish, JR.E.I.C., field engineer with Dravo of Canada Limited, Toronto, Ontario *(Construction of Foundations for Vernon Narrows Bridge.)*

Mr. McTavish graduated from the University of Toronto with a B.A. in civil engineering in 1955. He joined Dravo in 1955 and worked on marine and shaft sinking projects in Canada and the United States until mid 1958. Since then he has been employed in Dravo's estimating department in Toronto.

Mr. McTavish is a registered professional engineer in the Province of Ontario.

M. P. MacMartin, assistant research officer electrical engineering section, Radio and Electrical Engineering Division, National Research Council, Ottawa, Ontario *(The Development of an Electronic Detector of Flaws in Paper).*

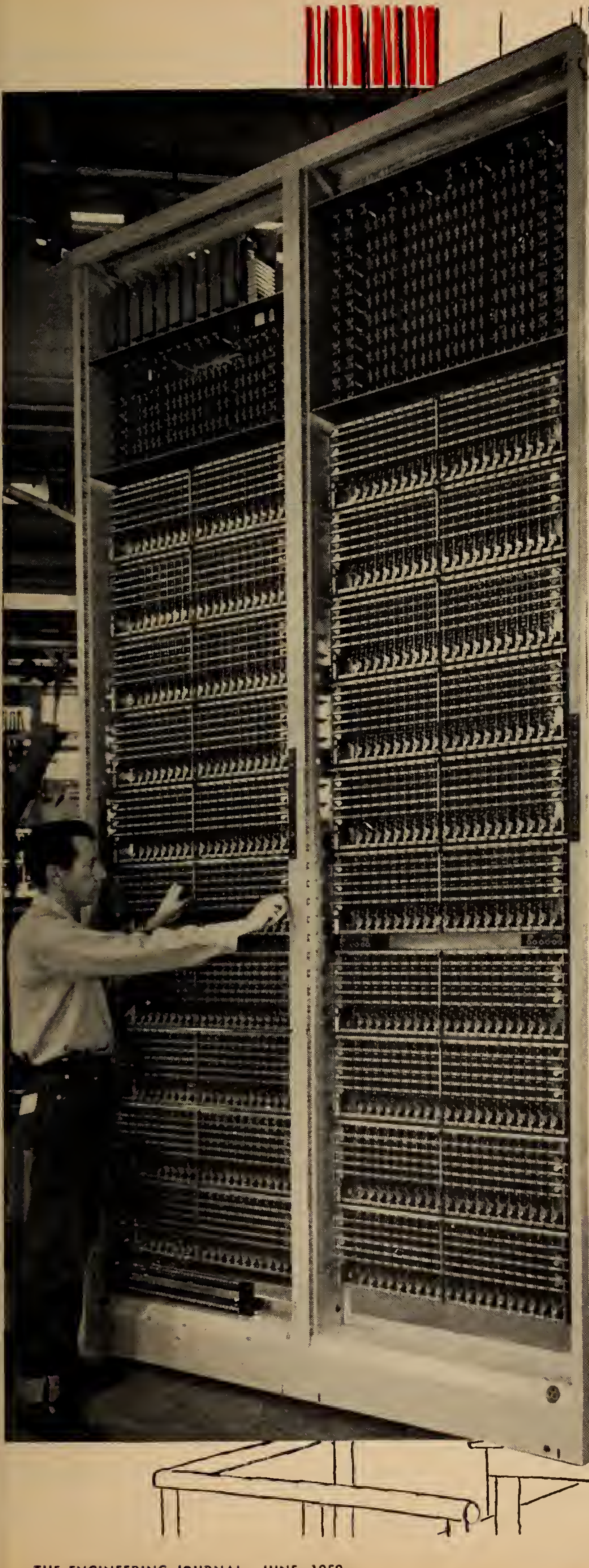
Mr. Martin graduated from Queen's University in 1950 with a B.Sc. (Hon.) in electrical engineering.

He has been working in the Electrical Engineering Section of N.R.C. since then.

N. G. Kusters, head, electrical engineering section, Radio and Electrical Engineering Division, National Research Council *(The Development of an Electronic Detector of Flaws in Paper).*

Mr. Kusters was born in Belgium and obtained his B.Sc. in mechanical engineering in 1937 and in electrical engineering in 1938 from the University of Louvain. His M.Sc. in mechanical engineering was obtained from M.I.T. in 1939.

We are indebted to the Faculty of the Ecole Polytechnique for their co-operation in the preparation of the paper which appears in this issue.



Message from the President

IF WE, as Canadian engineers, are not happy with the world, and in particular Canada, as we find it today, then let us remember that we are largely responsible for what we find.

We took the knowledge which research scientists had discovered for us, and as applied scientists and engineers used this knowledge to produce new materials, to improve processes, to reduce labour, and to find and develop new reserves of natural resources and raw materials.

If we now find that we have a surplus of goods, of labour and of natural resources let us not blame the politicians or economists or foreign competitors. Let us admit that we were too much absorbed with the problems of today and did not sufficiently plan for those of tomorrow.

We believe in private enterprise, in individual initiative and in acceptance of responsibility for our acts. Let us then prove our leadership by using our knowledge, experience and ability to look forward and to push ahead into new fields of endeavour for the future.

But let us lead not only in material things. We have been given education and training in how to get on with people, in how to manage large organizations and in how to conserve time and energy. Let us use some of our talents and time to assist in the solving of many of our community problems and in promoting cultural enterprises and in other public service. Only as we do this will we be recognized as truly members of a profession.

I sincerely appreciate the great honour which you have paid me in selecting me as President of the Institute. It is an office which over many years has been filled by very distinguished engineers. I shall earnestly endeavour to follow in their footsteps to the end that the prestige and service of our organization may be further enhanced. I look forward to your assistance and support and to the opportunity of working with you.

J. J. Hanna

J. J. HANNA, M.E.I.C.
President
THE ENGINEERING INSTITUTE
OF CANADA

ECOLE POLYTECHNIQUE
NEW ENGINEERING BUILDING

Specially written for this issue in collaboration with the University authorities.

The design and construction of these new quarters make an interesting engineering story. The main purpose of this article is to record the services, equipment and other facilities which are housed in the establishment.

FOUNDATIONS AND CONSTRUCTION

At the end of 1954 work started on the clearing of the rough, wooded, hillside site adjoining the grounds of the University of Montreal at the north-west end of Mount Royal. Excavation, which proceeded during 1955, revealed problems due to fissured and crumbling rock, and work proceeded until sound bedrock footings could be reached.

Figure 1 shows the plan of the building, which is conceived in four zones, subdivided into eight wings (A to H). Construction started in May 1955 with the foundations of wing A, and the first concrete pile at the north-east corner of this wing was driven to a depth of 35 feet before reaching solid rock. The rock under wings B, C, E, F, G presented no undue difficulties, though fissures and water-courses were present, but the base under H slopes rapidly to the west so that the two inside piles of the west wall are supported on a massive concrete slab. The wing D was perhaps the most 'awkward' since adjoining piles may be based on rock at depths which vary by 10 to 15 feet.

After establishing base lines, the wings A, C, and G were built separately, followed by the connecting wings B, D, E, F, H. Interconnection was made without any error. Wing G. was required at the very beginning to permit the installation of the heating system in the Boiler Room.

The reinforced concrete structure is fairly straightforward, but is generally very rigid and strong to deal with the loads imposed by equipment in various laboratories. The design takes into account the many large and small, steady and intermittent, known and unknown forces which occur in the building.

Of particular interest in the construction are the torsion-supported concrete canopy over the front entrance, the two circular staircases in the entrance hall, prestressed concrete tanks in the hydraulic labora-

Since its founding in 1873 l'Ecole Polytechnique has been prominent in the training of French-speaking engineers. Affiliated to the Université Laval de Montréal in 1887, the School has been an affiliate of the Université de Montréal since 1920 and could be regarded essentially as the engineering faculty of that body. It is constitutionally separate from it, having its own board of Governors and its own administrative officers. Through its contract of affiliation with l'Université de Montréal, it shares in the academic life of the campus and its degrees are given by the University. The curriculum leads to the degree of bachelor of applied science in the field selected by the student during the third year of his 5 year course. The curriculum and degrees are naturally fully recognized and particularly so by the Government of France as the equivalent of the courses and degrees of the major French schools: Polytechnique of Paris, Ecole des Ponts et Chaussées, Ecole Centrale, Ecole supérieure d'électricité, etc. With the financial assistance of the Government of the Province of Quebec, l'Ecole Polytechnique is now housed in entirely new quarters on the campus of the Université de Montréal.

tory, and a prestressed concrete base for the building structures laboratory.

In the old laboratories difficulty had been experienced with cracking of the walls and base of the hydraulic test tanks and channels. The new facilities were carefully designed in prestressed concrete, using cables in tension. The task was complicated by irregularity of the shapes involved and interruptions by expansion joints and openings.

The structural test laboratory at Lehigh University has a test base of 78 inches of reinforced concrete. Though loads in the Polytechnique laboratory will be comparable, it was necessary to avoid extensive and difficult excavation in hard rock, and consequently a 52-inch thick slab of prestressed concrete has been incorporated. Using a retarding agent and pouring at night to benefit from low temperatures, a strength of 8000 p.s.i. at 28 days was obtained. Vibration effects are localized by mounting the slab on a foam rubber cushion enclosed in a non-permeable membrane to avoid the deleterious effects of water.

HEATING SYSTEM

From the functional plan of the building (Fig. 1) the ideal location for the boiler room was the wing G. Consequent on this, the mechanical engineering department was also situated in the same wing. The installation of the heating and ventilating services was influenced by the aim of making the whole building a potential laboratory; that is, the students should be readily able to see the function of the whole scheme of distribution.

The total volume of the building is nearly 8.2 million cubic feet, and the floor area is 457,184 square feet. (Corridors, restrooms, stairways and elevators not included.)

Heating

The heating system is divided into eight zones. The two furthest zones (wings A, B, C) are heated by steam with differential exhaust and exterior temperature controls. The pump room and control panel are in wing B. The six zones in wings D to H have forced-circulation hot-water heating with external temperature controls. The heat exchangers and circulating pumps for this system are in the boiler room, and each zone has an exchanger fed with steam at 5 p.s.i., water temperature being controlled bv a three-way valve. Each feed pump is driven by an electric motor, and there is a standby steam-turbine pump which can feed two zones at a time in an emergency.

In addition to zone control, all lecture rooms are fitted with valves and thermostats to prevent local overheating when rooms are occupied; this also reduces fuel consumption.

In the wings A to E 'Wallvector' radiators are installed, and these are extended wall-to-wall in the administrative section of C for better appearance. Heating in wings F, G, H, which contain the chemical, metallurgical, mechanical and hydraulic laboratories, is by cast iron radiators

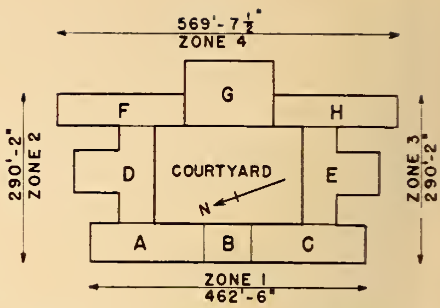


Fig. 1 — General plan of building.

or convectors. The main entrance and students' entrance are heated by ceiling air vents or cabinet installations, all separately controlled.

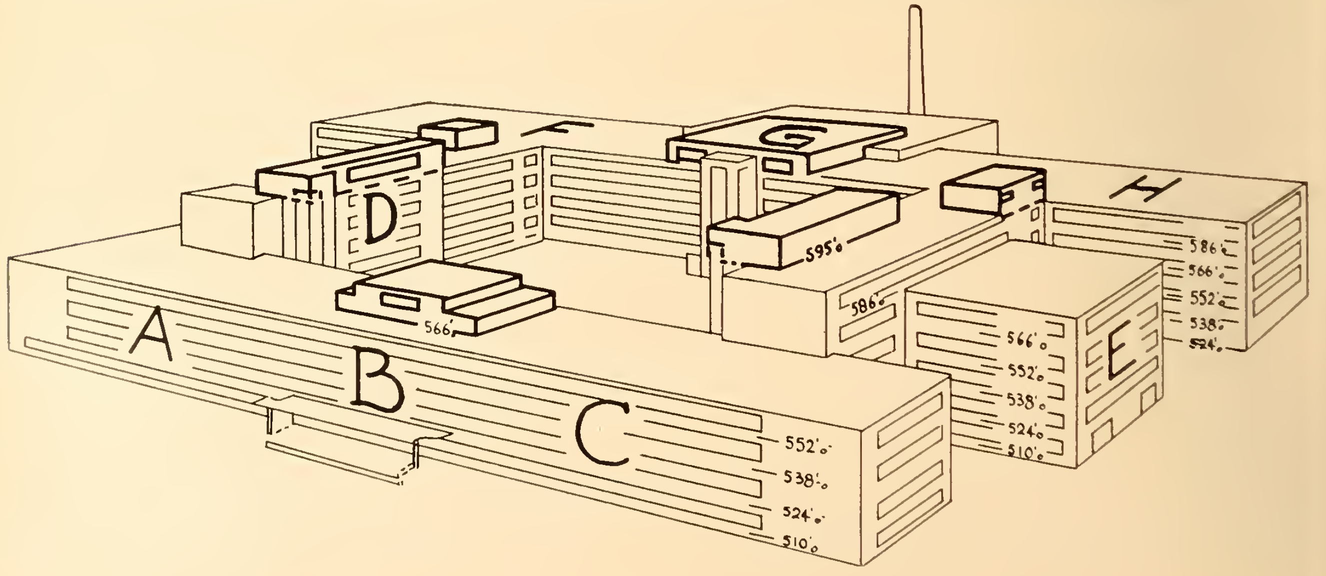
None of the piping is concealed in the permanent structure, but is readily accessible, where hidden, through removable panels. Most of the piping in wings D to H is open.

An unusual feature of the system is the use of wrought iron for most of the steam and water heating pipes. The main return pipes for steam condensate are of IPS brass, silver-soldered to 'Wallseal' unions. Some 14,900 square feet of steam radiation (E.D.R.) and 52,400 square feet of hot water radiation (E.D.R.) are installed.

Snow Removal

The ramp leading to the central courtyard is kept free from snow and ice by buried pipes through which heated glycol is pumped. The system is started manually, but temperature control is automatic. To prevent snow accumulating on the

Fig. 2 — General layout of building, showing position of penthouses for ventilating equipment (bold outline).



windows facing the yard, a somewhat simpler and slower-acting melting system is incorporated.

A sump in the courtyard is covered by steel plates which can be heated by steam at 100 p.s.i. Snow in the yard is pushed on to this, where it melts and is drained away.

Boiler Room

For heating the building and the ventilating air there are two water-tube boilers, each giving 25,000 lb. steam per hour at 100 p.s.i. Only one of these is needed in normal operation. A third boiler, giving 9000 lb./hr. steam at 250 p.s.i. and 50°F. superheat is linked to the heating system by a 250/100 lb. reduction valve. Steam from this boiler is supplied to specific laboratories.

The automatic burners operate on Bunker 'C' fuel with steam atomization, and use light oil for cold starting. There are two burners per large boiler; one for the 9000 lb./hr. unit. The oil is preheated and fed by electrically-driven pumps, with steam-operated pumps as a standby. Main oil storage is in two 15,000 Imp. gal. tanks, and there is one 1000 Imp. gal. tank for light oil. These boilers using oil as fuel can be easily converted to gas or coal.

All condensate from the heating system is received in a steel tank, whence it is pumped to a degasifier which uses live steam (or, if necessary, turbine exhaust steam). This unit, with a capacity of 35,000 lb./hr. at 160°-220°F., helps to prevent corrosion by removing oxygen and other non-condensable gases from the feedwater.

Feed pumps are electrically-driven with steam turbine standby. Each of the two large boilers is supplied by a pump of 35,000 lb./hr. capacity at 150 p.s.i.; the pump for the high-pressure boiler has a capacity of 12,000 lb./hr. at 300 p.s.i.

Combustion Control

A control panel centralizes instruments for recording steam delivery, water flow, combustion temperature, carbon dioxide, steam pressure, feedwater temperature and pressure, and ultimate steam temperature for the boiler with superheat.

All necessary safety controls are incorporated and oil, air, and feedwater are regulated automatically. A pump for each of the three feedwater lines injects the required amount of chemical water-treatment solution from a central tank. Quantities of solution (injected through solenoid-operated three-way valves) are controlled by steam usage through a mechanism linked to the combustion controls.

Fig. 3 — The torsion supported concrete canopy over the front entrance.

Domestic Hot Water

Two hot-water storage tanks (Monel), each of 1325 U.S. gal. capacity, have a reheat rate of 2160 U.S. gal./hr. at 40° to 140°F. using steam at 15 p.s.i. Two circulating pumps supply all hot water taps in the building.

In the summer, or when the steam boilers are not operating, a 342 kw./550 v. submerged-electrode boiler is used. This does not add to electricity costs, since the normal overall summer consumption is well below the minimum basic charge for electrical supply.

Temperatures at strategic points in each building zone, and the hot water feed and return temperature and pressure, can be read and adjusted if necessary at a central console in the boiler room.

Exhaust Stack

The octagonal stack, of radial brick faced to match the building exterior, is 150 feet high and six feet in diameter at the top. It is fitted with an external ladder, lightning rod, and air navigation beacon.

VENTILATION

The problem of ventilating such a large building was solved by considering the various wings A to H (Fig. 1) as separate units; each of these has a different function and type of occupation. Architecture and construction were also taken into account.

The final plan placed operating equipment in six penthouses built on the roof and situated as shown in Fig. 2. The areas served from these penthouses are noted in the table.

Ventilating Plan (Fig. 2)

Penthouse	*Area served*
B	Library
D	A; D (part)
F	D (part); F (part)
G	F (part); G; H (part)
H	H (part); E (part)
E	E (part); C

From these penthouses 68 different ventilating circuits operate: (i) 17 circuits of air feed and return, with some recirculation, for lecture rooms, drafting rooms, and administrative offices; (ii) 15 circuits of heated 100% fresh air, all evacuated to atmosphere, particularly for removal of fumes from chemical, metallurgical, and other laboratories (these 32 circuits, i and ii, can displace some 282,000 cu. ft. of air per minute); (iii) 36 circuits for exhaust of stale air from all toilets, dark-rooms, fume chambers in laboratories, etc., with total displacement of 113,000 cu. ft./min.

Ventilation for lecture rooms and offices is conditioned in winter only. The chemical laboratories can select rates of 10, 20, or 30 complete changes an hour, according to need. The library air is controlled for humidity to protect the many books and periodicals.

Most of the air circulation is at conventional rates, but wing C is supplied (from penthouse E) at a maximum of 4,000 ft./min. This system will be used for study by mechanical engineering students.

The dining area and students' quarters on the first floor of wing C are supplied with 100% fresh air. This can be heated by a novel 'thermowheel' exchanger, which can recover 60% to 80% of the available heat from the stale exhaust air. The system will be used for laboratory studies.

All ventilation is controlled centrally from the boiler room, using a high-frequency signal system instead of conventional cable connections to the penthouses. This system is described further under Electrical Equipment. The control program takes into account the time of occupation of the various rooms and laboratories.

Noise and vibration from the penthouse installations are practically eliminated by the use of rubber mountings and cork bases under the machinery.

Fig. 4 — Outside storage tank of propane gas.

WATER AND SERVICES

The City of Montreal provided a 16-inch pipeline from the reservoir at the top of Mount Royal (elev. 655 ft.) via the Mount Royal cemetry which adjoins the upper limits of the Polytechnique grounds. This pipeline delivers water at 45 p.s.i. to a header with the necessary valves from which one eight-inch line runs to the University grounds and a similar line enters the Polytechnique building between wings G and H. Here two centrifugal pumps boost the pressure to 80-100 p.s.i.

Instead of the conventional hydraulic distribution systems incorporating air reservoirs, circulation is controlled by a centrifugal pump driven by a variable-speed electric motor to meet any fluctuations in demand. Should there be any failure in the 500 U.S.g.p.m. pumps or the 20 h.p. motors, a bypass gives direct supply from the 45 p.s.i. source. There is thus no need for a separate storage tank.

In an emergency, the large quantities of water in the storage tanks for the hydraulics laboratory can be pumped into the central heating system.

Water Distribution

Hot water circulation is conventional, all pipes being accessible through doors in cavity walls or false ceilings.

In the laboratories, there are two hot and cold water circulations; one for the use of the laboratory equipment and the other for domestic uses, and they are specially identified to avoid the possibility of siphoning contaminated water into the main supply. (The City of Montreal will not accept the use of vacuum breakers.)

All hot and cold water piping is of copper, class K.

Waste and Drainage

Laboratory waste which may be chemically contaminated is discharged through Duriron piping. The system has been designed to minimize the amount of this material required.

Three parallel 15-inch drains join a 24-inch main running in front of the building and eventually down to the city mains on Maplewood Avenue. The 15-in. drains run: (i) from wing F through D and A; (ii) from H through E and C; (iii) from G via the central courtyard, whence run-off is collected, and out through B. This drain also takes in any overflow from the hydraulic laboratory.

Special Laboratory Services

Special services include steam, compressed air, vacuum, distilled water, and gas.

Steam — The chemical and thermal machines laboratories are supplied with steam at 250, 100, and 15 p.s.i. Several other laboratories have 100 and 15 p.s.i. supplies.

Compressed Air — All requirements for compressed air are supplied from the boiler room by two compressors of 180 cu. ft./min. capacity (40 h.p. motors) and one compressor giving 365 cu. ft./min. (75 h.p. motor). An intermediate cooler is provided, plus a special cooler for dehumidifying the air.

Vacuum — Continuously-available vacuum of 25 in. Hg is provided in laboratories from a central system in the boiler room. Two 280 cu. ft./min. vacuum pumps are driven by 20 h.p. motors.

Distilled Water — A central automatically-controlled gravity-fed supply of distilled water is provided from the penthouse on wing F. Capacity is 10 U.S.g.p.h. from a 26 kw. heater, with storage for 300 U.S. gal. in a tin-lined tank. All piping, unions, and valves are of polythene.

Propane Gas — The demand for gas, which is seasonal, is not enough to justify the cost of a link to the gas mains on Maplewood Avenue, and therefore propane gas is used for laboratory supplies. From a 7000 U.S. gal. storage tank outside the building, 30 U.S.g.p.h. can be vaporized at 20 p.s.i., with automatic operation. Gas in the main distribution lines in the building is at 20 p.s.i., but between these lines and the laboratory outlets are safety and reduction valves to give a supply at 6 oz./sq. in.

ELECTRICAL SERVICES

The provision of adequate electrical supplies for an engineering school such as this presents more problems than does the design for a large commercial or public building. Different laboratories have widely differing needs, and there must be considerable flexibility to meet new demands which may arise.

Main Supply

The main supply comes from two 12 kv. Hydro-Québec lines. The 2500 ft. link between these lines and the internal sub-station is by: (i) 1000 ft. of underground line beneath the Polytechnique grounds; (ii) 1500 ft. of overhead line following the route of the 4 kv. lines that supply the University. This latter installation involved lowering the 4 kv. lines by some 10 ft. and adding the 12 kv. line above them without interrupting the existing supply.

Unit Substation

The unit substation is under the electrical laboratories in wing D and consists of Metalclad type equipment divided in three sections:

i) Potheads, disconnects, air breakers and Hydro-Quebec measuring equipment are grouped together in the first section. From this section, 12 kv. busbars supply the transformers.

(ii) Two main transformers for lighting and power supply are 3-phase, 12000/550 v., 1500 or 2000 kva. capacity, with convection or forced cooling. These transformers supply 2000 amp. busbars.

(iii) Three transformers and voltage regulators supply the electrical, electronic and physics laboratories, and provide 220 v. 3-phase power. The equipment is: a 3-phase, 500 kva., 12000/550 v. transformer with 54 kva. induction voltage regulator; a 3-phase, 225 kva., 12000/220 v. transformer with 25 kva. regulator; and a single-phase 200 kva., 12000/110-230 v. transformer with 20 kva. regulator.

This transformer station, totalling 5000 kva., was specially designed for Ecole Polytechnique and should meet demands for several decades to come.

The station is illuminated, and windows of special shatter-proof glass permit inspection of the main components.

Direct Current Supply

Direct current is supplied to the laboratories from sixty 685 amp.-hr. lead oxide accumulators, which are maintained by a 400 amp., 125 v. charger with silicon rectifiers.

Distribution

The main distribution boards are in the electrical engineering laboratory above the transformer station. There are five boards for distribution from the five transformers; one board for d.c. supply; one for Hydro-Québec recording instruments; and one board for supplies at variable voltage and frequency.

There are seven secondary boards for lighting supplies, each comprising three single-phase 550/110-220 v. transformers at 75 or 100 kva., according to load in the section concerned. One secondary board for power supply delivers 350 h.p. to the boiler room, 350 kw. to electrical steam generators, 600 h.p. to the hydraulics laboratory, and an estimated 750 h.p. to the gas dynamics laboratory. This board is supplied simultaneously by two busbars, with a switching system to distribute the load evenly between the two transformers.

Lighting

Lighting represents about 40% of the total cost of electricity, and particular attention was paid to its design and installation. Adequate illumination and accessibility were the main considerations, but appearance was not neglected.

Lighting levels are (in foot-candles): lecture rooms 40; drafting rooms 50; laboratories 30. Altogether, some 3800 incandescent lamps were required, of which 600 were of one type for the lecture rooms.

The corridors, administrative offices, and library are lit by rapid-start fluorescent lamps. Those in the library are recessed in the ceiling beneath white reflectors and are covered with transparent glass panels which incorporate translucent honeycombed diffusing strips to give an even, shadowless distribution of light. This is one of the first installations of its kind in the country.

The access roads are lit by reflectors similar to those designed for aircraft runways or bridges, mounted only three feet above ground level.

Fig. 5 — The accumulator room.

Laboratory Supplies

All laboratories have supplies of 550 v. 3-phase; 220 v. 3-phase; 110-220 v. single-phase; and 125-250 v. d.c.; usually via a separate board for each department. These boards are also connected by two 200-amp. lines to the secondary board in the electrical engineering laboratory which provides variable voltage and frequency.

In addition, different voltages are supplied for individual requirements; for example, the engineering physics department has a 12 v. d.c. supply, and physical chemistry has a source at 1000 c.p.s.

Remote Control

An interesting feature is the system used for remote control of services. Because of the distances involved, ventilating installations are in six separate penthouses, and the exterior lighting is divided into three sections (rear parking lot, central courtyard, and access roads), each supplied from different points. Centralized control is achieved by the use of carrier waves, thus eliminating the considerable lengths of cable necessary in conventional systems.

An alternator in the electrical laboratory imposes frequencies of 2965 and 3803 c.p.s. on the entire 550 v. and 110/220 v. system. This output is coded and controlled manually or automatically, according to an established schedule, from a console in the boiler room. Relays at any point in the distribution system receive the coded output and accept or reject it according to conditions, thus starting or stopping the various ventilating circuits. Seventy-two relays may be installed at present, with provision for a further thirty-six.

Intercommunication

Rapid communication is essential in such a large building, and two distinct systems have been installed to augment the heavily-loaded regular telephone facilities.

(1) *Calling System* — There is a loudspeaker network over which the central telephone operator can make announcements, either generally or to local speakers. Musical notes at 800 and 2000 c.p.s. will be broadcast

over the general system to announce the start and finish of class periods; these operate from the central timing unit.

(2) *Internal Telephone* — Offices in the front section of the building, including administration, and those of department heads are connected by an automatic telephone system. In addition, each department head or his secretary can reach his staff by a local telephone circuit.

THE ENGINEERING LABORATORIES

The move by Polytechnique into its new quarters coincides with the introduction of a revised program of studies leading to full specialization courses. *(The Engineering Journal,* Oct. 1958, p. 93.) The eight fields of engineering now offered and which are described in the above reference, are: civil, mechanical, electrical, chemical, metallurgical, mining, geological, and engineering physics.

Some of the laboratory facilities and equipment available to the students of these various fields will be described in the remainder of the present article.

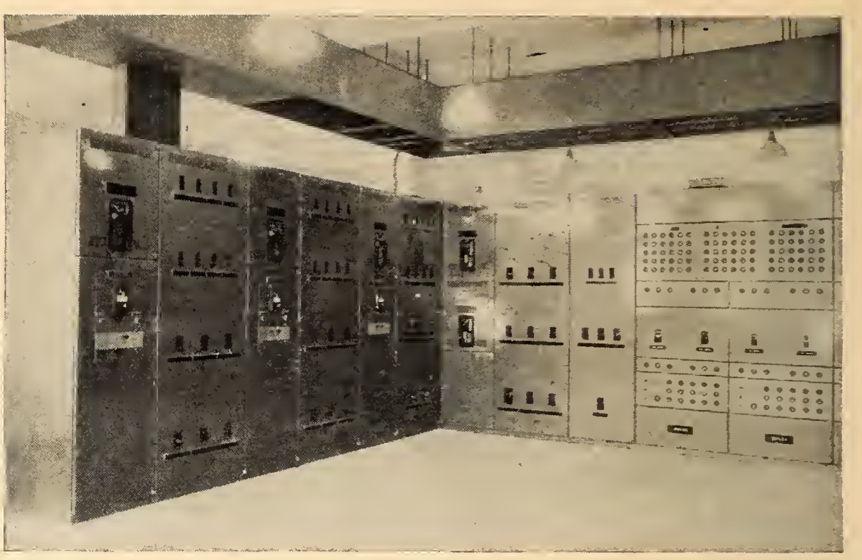


Fig. 6 — A section of the main board. Left: three regular tension panels; at the back: the continuous current panel; at right: the panel for variable tension and frequency.

CIVIL ENGINEERING

The civil engineering department has four divisions: surveying, sanitary engineering, hydraulics, and public works.

Division of Surveying

The laboratories of the surveying division, which cover 3400 sq. ft., are subdivided into three groups: survey, geodesy, and photogrammetry and cartography. The first deals with the theory and operation of instruments, and includes a test bench for transits and theodolites. The geodesic laboratory includes equipment for standardization of chains and checking of levels.

The photogrammetry laboratory which is being established will be equipped with a Multiplex machine and various stereoscopes. Easy access will be provided to the roof, from which astronomical observations may be made and an opportunity given to the students to familiarize themselves with the various instruments.

A maintenance and repair shop is provided.

Division of Sanitary Engineering

Equipment is now being ordered to establish the laboratory with the necessary instruments for research and advanced studies pertaining to water purification and sewage treatment. Both the chemical and bacteriological aspects can be studied with the equipment at hand. For the study of the hydraulic problems encountered in Sanitary Engineering, the facilities and modern equipment of the Hydraulics Laboratory are readily available.

Division of Hydraulics

The hydraulics laboratories occupy the first three floors of wing H, covering some 27,000 sq. ft.

Six pumping units have a total capacity of 18,000 U.S.g.p.m., and four of these units can be operated in parallel. All pumps in the laboratory are supplied from prestressed concrete storage reservoirs with a total capacity of about 150,000 U.S. gal. The construction of these reservoirs has been mentioned earlier.

Four different turbines are available for study: a 10 h.p. vertical unit with interchangeable wheels; a 30 h.p. horizontal turbine for cavitation studies: an impulse turbine with a capacity of 6 h.p. under 250 ft. head; and a horizontal Francis unit of 9.7 h.p. under 100 ft. head. The various hydraulic circuits are provided with flow-measuring equipment such as Venturis, Dall tubes, and Pitot tubes.

Two steel measuring tanks mounted on weigh-scales, each with a capacity of 40,000 lb., are used for accurate calibration of the flow-metering equipment and also for efficiency tests on a vertical pump and other equipment.

Several test channels have been provided in the laboratory. A prestressed concrete channel on the second floor is 185 ft. long, 8 ft. wide, and 6 ft. deep, with observation windows in one of the vertical walls; it is being equipped with a motor-driven carriage which runs on accurately aligned rails. This channel will be used to calibrate current meters and for testing ship models, and models of hydraulic structures. Two glazed channels, equipped with weirs and supplied by constant-level reservoirs, will be used for studies of flow in open channels and also for testing scale models. A channel, 75 ft. long, will be utilized for the study of sediment transportation. Two tilting flumes will also be provided.

In addition to an instrumented wave tank, seven other test channels are provided in the laboratory: intake and discharge flumes for the vertical turbine and others for the study of density current, stability of earth dams, and three small steel channels with weirs.

Division of Public Works

Four laboratories are grouped together in the Division of Public Works. These are: soil mechanics, highway materials, concrete and construction materials, and structures.

Soil Mechanics — This laboratory has been expanded considerably during the past twenty years and much work done in the relatively new field of soil mechanics. The present laboratories are well equipped to continue this teaching and research work, complemented by field studies and research on methods of measurements of soil properties "in situ".

Apart from the standard equipment required for the identification and classification of soils, apparatus is provided for the study of permeability, capillarity, frost action and compaction. Various types of triaxial compression machines, direct shear machines and oedometers are also available for work on the shear and consolidation characteristics of soils. Some of this equipment has been developed or modified in the laboratory in order to carry out research work in this and other related properties.

Highway Materials — This laboratory adjoins those of soil mechanics and is provided with all the equipment needed for the study of the physical and mechanical properties of the materials commonly used in the construction, maintenance or repair of roads. One section is concerned with the study of bituminous mixtures, with the aid of Marshall apparatus.

In conjunction with the soil mechanics laboratories, research work is carried out on soil stabilization and on frost action.

Concrete and construction materials — The laboratories for testing concrete and construction materials are well equipped for a variety of tasks. Materials tested include cement, aggregates, mortar, concrete, masonry, wood, structural steel and so on.

An efficient concrete mixer of a capacity of 5 cu. ft. and a high-frequency vibrator are available. Concrete test beams and samples can be cured in a room (25 ft x 10 ft x 9 ft high) in which the temperature and relative humidity are accurately controlled.

A cold room (18 ft x 8 ft x 9 ft high) has also been installed for research work on concrete and construction materials. The temperature can be controlled to $\pm 1°F$ and can be lowered to -60°F. The high-capacity refrigerating unit can be also connected to a mobile chamber in which tests of structural units can be made at low temperature.

A freezing and thawing unit capable of running tests according to the four ASTM methods is under construction.

Apart from the standard apparatus for cement and concrete testing, the available equipment includes various types of extensometers, high precision comparators, creep and shrinkage measuring devices, and apparatus for the determination of dynamic moduli of elasticity of concrete and other construction materials.

Structures — A wide variety of tests may be performed in this laboratory. A universal testing machine of 220,000 lb capacity equipped with a pulsator may be used for either static or dynamic loading. The laboratory is equipped with another universal testing machine of 100,000 lb capacity, a 400,000 lb press for compression tests and a 1,100,000 lb press capable of accommodating specimens up to 16 ft in height.

Tests on structures of various shapes may be carried out on the prestressed concrete testing bed. This bed is 60 ft long, 19 ft wide, and 54 in thick. Three-inch diameter bolts of special alloy steel are embedded in pairs in the concrete, the distance between pairs of bolts being 5 ft longitudinally and 4 ft in the transverse direction. Structural steel frames may be fixed to the bolts by means of special adapters so that structures up to 60 ft long can be tested. The structural elements may then be loaded by hydraulic jacks fixed to the steel frames. These jacks can operate in any chosen direction. Both static and dynamic tests may be carried out and on account of vibrations the bed rests on a special dampening foundation. The testing bed is designed for vertical loads of 500 tons or horizontal loads of 750 tons at points 8 ft above the top of the bed. A 10-ton travelling crane services the testing bed. The capacities of the high-precision hydraulic jacks which form part of the test equipment range from 2.5 tons to 100 tons. A range of steel sections for building up the loading frames completes the equipment for this work.

Various types of extensometers are available and using electronic measuring instruments coupled with special strain gauges, an accuracy of 1/1,000,000 in./in. may be attained.

Fig. 7 — A section of one of the well designed laboratories.

MECHANICAL ENGINEERING

Under the new program of studies, mechanical engineering is a separate course whereas, from 1943 to 1958, there was only a partial specialization in an option called mechanical-electrical engineering.

Equipment

The equipment brought by the department from its previous quarters includes a Diesel engine, other internal combustion engines, an air compressor, a steam engine, blowers and ducts, a refrigerated chamber, and various pieces of machinery. A recent, and valued, acquisition is a steam turbine with condenser and associated equipment with which many experiments can be carried out.

As mentioned in the sections dealing with heating and ventilating, the boiler room and other equipment in the new building will be used for extensive studies by the mechanical engineering department.

Further new equipment will include installations for advanced studies in gas dynamics, and new internal combustion engines with complete instrumentation.

Additional facilities will be installed as required, and the aim of the department is to provide those who wish to proceed to the Master's or Doctor's degree with all the equipment that is found in other schools of engineering.

Laboratories

The laboratories and offices of the mechanical engineering department are situated on two floors of wing G, which also contains the boiler room, and part of wing F (Figs. 1 and 2). A comprehensive series of instruments is provided for the observation and control of the boilers and all the other equipment which has been described earlier.

Adjoining the boiler room on either side are two 2675 sq. ft. laboratories, one for the study of gas dynamics, the other containing the Diesel and gasoline engines, compressors, and similar equipment. Opposite the boiler room are a store for equipment and tools, and what is now known as the research laboratory, to be used for future expansion.

At mezzanine level in the boiler room are the hot water storage, electrical heater, and circulating pumps, with facilities for studies of heat transfer. Adjoining the mezzanine at the same level are two laboratories each of 2675 sq. ft. area. The first of these will house equipment for the study of ventilation, air conditioning, refrigeration, and heat transfer, with appropriate controlled-condition chambers. The second area will contain the new steam turbine, condenser, and pumps, together with further ventilation and refrigeration apparatus.

Across the corridor from these laboratories are the departmental offices, which extend partly into wing F, a room for storage and calibration of instruments, a design section, and a lecture seminar room.

ELECTRICAL ENGINEERING

The new course in electrical engineering up to the B.Sc. degree combines both the fields of electrical power and communications (electronics), in contrast to many courses which tend to provide specialization in either field.

Laboratories

The electrical engineering laboratories occupy most of wing D, the transformer sub-station being at the lowest level. The equipment in this sub-station has been described under Electrical Services, as have many of the other facilities which will be available for study.

On the higher floors are laboratories for electrical machines and measurements, and communications. The entire fourth floor is devoted to electronics and electronic-physics, particularly for research and post-graduate studies. Part of the fifth floor is to house an electronic computing centre.

ENGINEERING PHYSICS

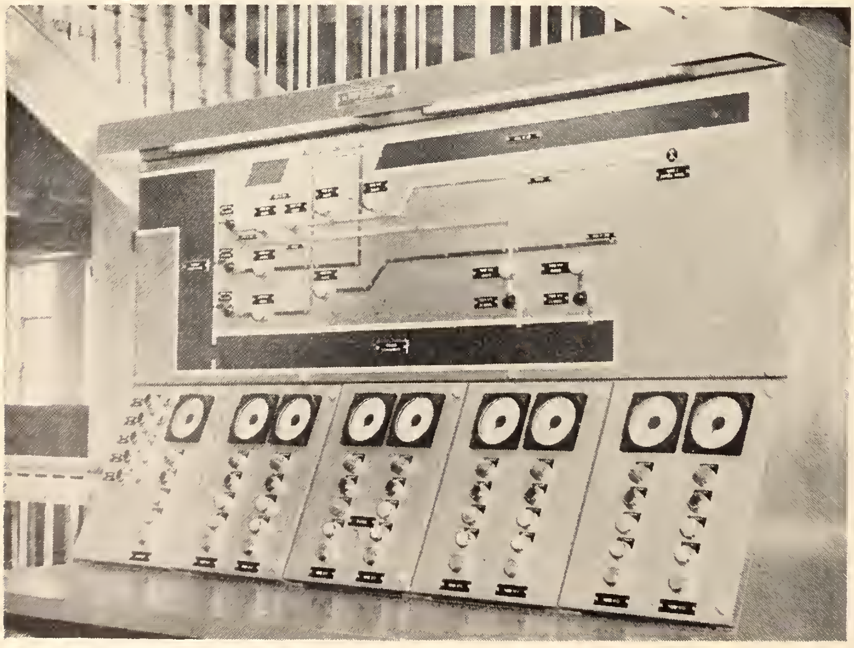
Instruction in engineering physics is a new departure for the Ecole Polytechnique. The approach is more fundamental and analytical, and rather less technological, than in the classical fields of engineering. The curriculum includes physical chemistry, thermodynamics, heat transfer, nuclear physics, metallurgy, nuclear engineering, solid state physics, and the study of electronic computers.

Laboratories

The engineering physics laboratories are equipped for the study of all necessary aspects of modern physics, and a physical measurement centre will provide such apparatus as: optical spectrometer, X-ray diffractometer, mass spectograph, electron microscope, and so on. Some of these facilities may be shared advantageously by other departments such as physics, chemistry, metallurgy, mining, and geology.

The laboratories of the electrical engineering department are also available to engineering physics students for work in fields of common interest.

Fig. 8 — Central control console for operating pumping units and motor-operated valves.



CHEMICAL ENGINEERING

The chemical engineering department includes a general chemistry section as this department has to supply all the chemistry courses needed for chemical engineering and for other branches of engineering.

Chemistry Laboratories

The chemistry section includes laboratory facilities that will be used by all the students during their initial training and later by students in certain branches of engineering. The largest laboratory of this section is the general chemistry laboratory which covers an area of 6,200 sq. ft. and which can accommodate easily 120 students at one time. The other principal laboratories of this section are those of physical, organic and analytical chemistry which total 8,600 sq. ft. To serve this chemistry section, there are the necessary preparation rooms, balance rooms, work shops, stores and also some research laboratories having a total area of 5,000 sq. ft. This section also includes the Montreal laboratory of the Department of Mines of the Province of Quebec.

Chemical Engineering Laboratories

The chemical engineering laboratory which is the most important of this section has a floor space of 40 by 60 ft. with an average height of two floors but with a raised section of 16 by 15 ft. giving a height of three floors. At first floor level runs a mezzanine floor with a central opening of 27 by 40 ft. This arrangement will accommodate pilot plant size industrial equipment such as heat-exchangers, distillation columns, absorption columns, evaporators, driers, filter presses and so on.

The chemical engineering section also includes a laboratory for industrial control and the study of recording instruments, a research laboratory in unit operations and a high pressure equipment laboratory. There is also in this section a large laboratory for applied chemistry with two smaller laboratories, one for analytical work and the other for instrumentation analysis. The usual service rooms as work shops, stores etc. are also provided in this section.

Two special laboratories have been reserved for work on corrosion and the roof of the rear wing of the building has been prepared to install benches for an atmospheric corrosion site. About 20,000 sq. ft. are available for benches on which test panels of metals and coatings will be studied.

Space has been also allocated for a physical measurement center which will be under the direction of the department of physics and chemistry. This center has already been referred to under engineering physics.

All the laboratories of the chemical engineering department have the usual necessary services as gas, vacuum, compressed air, etc. plus a three rates ventilation system that will satisfy any requirements.

METALLURGY

The great developments in the extraction and processing of metals in the Province of Quebec have laid particular emphasis on the operations of the new department of metallurgy, and facilities have been provided for undergraduate teaching and for postgraduate study and fundamental research in the various fields.

Laboratories are organized for studies in the three main phases: extractive metallurgy, metal working, and fundamental metallurgy.

Extractive Metallurgy

The extractive metallurgy laboratories, which are in addition to those for mineral treatment belonging to the department of mining engineering, include a general laboratory and special labs. for mineral refining and metal extraction. Part of the main laboratory is used for chemical treatment of minerals.

The laboratory used for work on the extraction of metals is equipped with furnaces heated by electric arc, oil, gas, electrical resistance, and vacuum furnaces. It also contains the equipment required for the extraction of metals, such as zinc, by the electrolysis of aqueous solutions or such as aluminum, by the electrolysis of fused salts.

Refining and Treatment

The refining and further treatment of metals is carried out in several laboratories, including the electrolysis section. Melting and casting are mainly done in the furnace rooms mentioned above.

For the metal treatment experiments the facilities are planned to include equipment for forging, laminating, extruding, wire-drawing, and welding.

In the heat-treatment section are furnaces with controlled atmosphere, high- and low-temperature furnaces, annealing furnaces, and soaking furnaces.

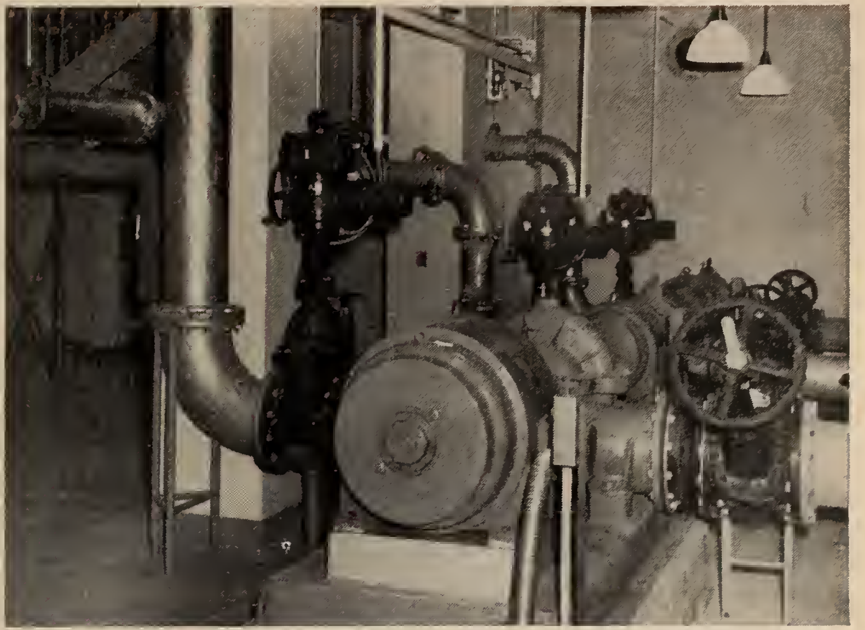


Fig. 9 — Three pumping units having a total capacity of 10,000 U.S. g.p.m.

Fundamental Metallurgy

In the field of fundamental metallurgy, chemical problems are investigated in the extractive metallurgy laboratory. Facilities are provided for physical metallurgy, pyrometry, and microscopy. Another section is equipped for investigations by ultrasonics, X-rays, gamma-rays and radioisotope tracers.

The equipment necessary for this work includes polishers, microscopes, and metallographic apparatus, and an electron microscope is to be added. For radiography, generators of X-rays and gamma-rays are to be provided.

Special Features

To assist in the efficient operation of the laboratories several features have been given special attention. To deal with the dust and fumes which are an inherent problem in metallurgical operations, special drainage is provided in certain of the floors so that they can be flushed down with large quantities of water, and correct ventilation and exhaust have been carefully studied.

A flexible general layout is provided by the use of specially-constructed interior walls which can easily be removed and equally readily rebuilt.

MINING ENGINEERING

Mining engineering, which originally formed a partial specialization with metallurgy, later with geology, is now the concern of a separate department. Instruction is given in such field subjects as surveying, excavation, drainage, and mine management, as well as in the extractive processes essential to the mineral industry.

The new course takes into account the importance of mineral dressing and the department is equipped to study the various processes in addition to the facilities of the department of metallurgy.

Laboratories

The various sections of the mineral dressing laboratories cover a total area of some 12,600 sq. ft. One section is concerned with crushing, screening and sampling; another deals with methods of separation and concentration by gravity, jigging, Wilfley table, Humphreys, spiral, etc. Electrical separation by dry and wet methods, electrostatic precipitation, flotation, and other means are studied.

Cyanide extraction and similar processes using aqueous solutions are housed in a separate room fitted with driers, storage and settling tanks, filters, and so on. A group of continuous-analysis equipment enables the student to follow the course of the various processes and to make necessary adjustments.

The laboratories are fully equipped for the complete study of such problems as ore enrichment, and more extensive facilities than previously will be available for work on the 'new' and rarer metals.

GEOLOGICAL ENGINEERING

In addition to teaching the new specialized course, the department of geological engineering provides facilities for students of geology from other departments and for part of the course of the Faculty of Geology at the University of Montreal.

Essential for the study of geology, the department has gathered an extensive and varied collection of rock and ore samples, maps, and photographs, which are housed on either side of the department's own library.

Laboratories

The general mineralogy and geology laboratory is used for the elementary study of rocks and minerals. It can accommodate 100 students. In the crystallography, mineralogy, and petrography laboratories, crystallography is studied by use of crystal models and optical goniometer. Rocks, eruptive and metamorphic ones in particular, are studied with binoculars and petrographic microscopes, in thin sections, by polarized light.

Similar facilities are provided in the laboratory for the evaluation of mineral samples from the principal mining centres of Canada and elsewhere. Here, ore specimens are studied by polished sections under the ore microscope and by microchemical tests.

For the study of sedimentation, equipment includes binoculars, petrographic microscopes, precision balance, hot plates, evaporating baths, filters and a centrifuge. The same section is also used for Stratigraphy, Historical Geology and practical Paleontology, including the identification of fossils which involves the use of small drills and tools for removing the fossils and preparing them for examination.

Adjacent to the department's library is a map room with all facilities for map storage, examination and tracing.

Lectures and labs in Physiography, Structural Geology and Geology of Canada are given in a class-room having access to the map room.

Geophysics

Equipment now in use for instruction in geophysics includes dip-needles, magnetometers, Geiger counters, and scintillometers. Further equipment for a proposed research program will be bought or made locally.

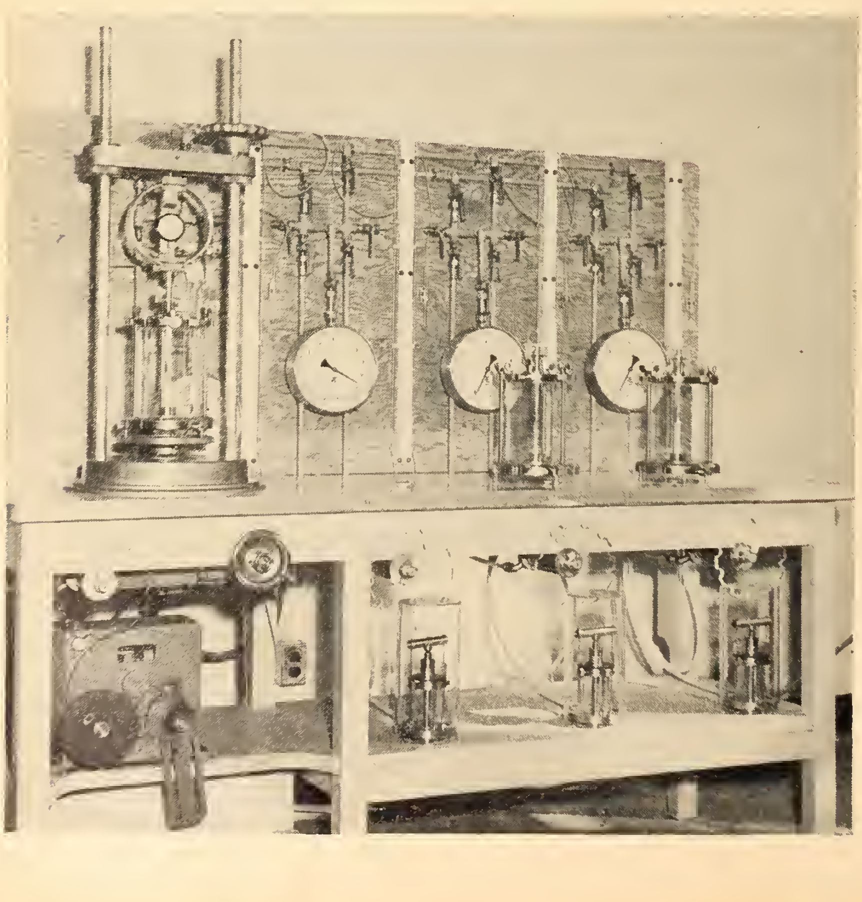
Research

Each professor in the department has his own small laboratory for personal research or work by one of his students. Other rooms are also available for graduate students.

The main research laboratory features the latest apparatus for the study of minerals and other crystalline materials by means of X-rays, diffraction, and spectro-fluorescence. Refractive indices are measured by the double variation method, with provision for monochromatic illumination, universal and heated stages.

Other equipment includes balances of a wide range of sensitivity, a Vreeland spectrometer, an isodynamic separator for magnetic minerals, a microscope for microphotography, etc. Equipment for the study of clay minerals by differential thermal analysis and various other research instruments are to be ordered in the near future.

Fig. 10 — Triaxial compression apparatus.



The Library

The library is an important feature of the Ecole Polytechnique and occupies a select position on two floors of the north-east end of the main entrance wing. The total area occupied is some 26,000 sq. ft.

On the first floor of the library, entered from the main hall, a central aisle extends the full length. The reception counter and administrative offices are near the entrance and opposite a room with table space for 32 persons, and containing the current year's issues of up to 1000 periodicals. Adjoining this is the general reference system, used for locating required publications.

In the middle section, about one-third of the total area, bookshelves run at right angles from either side of the aisle, with room to walk round the outer ends. Space is provided for five years issues of periodicals preceding the current year; earlier issues are stored on the second floor. The books are classified by the universal decimal system, and the shelves are marked for quick identification of the various sections. There is space for about 35,000 books.

At the far end of this floor is the reading room, which can seat 96 persons. This area is far enough away from the reception counter to avoid any disturbance to the readers, and the floor and ceiling of the library are insulated to minimize noise from people moving around.

A door in the library leads to part of wing D, in which is a room for reading microfilms, a bookbindery, and rooms for library staff.

The Second Floor

A metal staircase leads from the main library to the second floor, which also has a central aisle and is fitted with removable bookshelves, permitting considerable flexibility of arrangement.

In addition to issues of periodicals earlier than those held in the main library, this floor is used for storage of official publications from various countries and other volumes that are referred to less frequently. About

(Continued on page 68)

CAPACITOR DEVELOPMENTS IN GREAT BRITAIN

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IMPREGNATED PAPER CAPACITORS

PAPER, IMPREGNATED with oil or other suitable insulating impregnant, remains the principal dielectric material used for power capacitors, and also for many radio capacitors. Over the last fifty years major improvements have been made in the quality of capacitor paper tissue, and of the oils and other impregnants. Despite the development of many synthetic dielectric polymers, few of them can compete economically with impregnated paper in the power capacitor field.

Among electrical components the capacitor can claim a respectable antiquity. The first capacitor antedates the first dynamo and the first cable by more than a century.

It was in 1746 that Pieter van Musschenbroek of Leyden wrote to his friend Réaumur, "I wish to inform you of a new, but terrible experiment, which I advise you on no account personally to attempt. I had suspended by two blue silk threads, a gun barrel, which received electricity from a glass globe. From the opposite end of the gun barrel hung a brass wire, the end of which entered a glass jar, which was partly full of water. Suddenly I received in my right hand a shock of such violence that my whole body was shaken as by a lightning stroke. The vessel, although of glass, was not broken, nor was the hand displaced by the commotion; but the arm and body were affected in a manner more terrible than I can express. In a word, I believed that I was done for". Thus the first capacitor, the *Leyden jar*, was accidentally discovered.

From those early days when electricity was but a toy, through the pioneer researches of Faraday, Franklin, Kelvin and others, to the modern electrical and electronic industries, the capacitor has remained an almost inevitable component of electrical experiments and electric equipment.

Today the manufacturer of capacitors supports an industry with an annual production of $20 million in Great Britain, of $79 million in the U.S.A., and of $9 million in Canada. The capacitors range from the massive capacitor banks, such as that at Sorel, Quebec installed for power factor correction, as shown in Fig. 1, to the miniature tantalum oxide capacitors less than the size of a pea used in transistor circuits.

As in other fields of engineering endeavour the rapidity with which new types of capacitors are being developed, and new scientific techniques are being applied to capacitor design, is greater than at any previous time. The object of this paper is to present a broad account of current capacitor research and development in Great Britain.

Paper Research

Research is in progress on the fundamental properties of cellulose papers, and on new types of "paper" using man-made fibres such as polystyrene, polyethylene terephthalate (Terylene), polytetrafluoroethylene (P.T.F.E.) and nylon, in combination with glass fibre or cellulose. A complete pilot-scale paper-making machine enables experimental papers to be made in the laboratory. Detailed studies are made of the electrical properties (permittivity, power factor, insulation resistance, breakdown strength, etc.), the physical properties (uniformity, density, porosity, transparency, mechanical strength, surface texture, shrinkage, effects of temperature and humidity, etc.) and of the chemical composition of experimental papers and of paper obtained directly from the suppliers. In this manner new types of paper with improved properties are being developed.

The *Talysurf* instrument is used for recording the surface texture of the paper i.e. the hills and valleys of the paper surface. A light stylus traverses the specimen paper and the surface profile irregularities are magnified and recorded. Fig. 2 is a typical record showing the differences in surface texture of different papers.

It has been shown by tests and microscopic examination that impulse breakdown of an oil/paper dielectric tends to occur at points where the paper is thinnest, even though these thin areas are so small as to be only one or two mil. in dimension. The paper is, of course, purchased on the basis of its average thickness, though its electrical performance is determined by these microscopic areas of minimum thickness. Thus the *Talysurf* records give a clear demonstration of the volume of paper which is being uselessly purchased.

Oil Research

Mineral oil is still the principal impregnating liquid used in paper capacitors. Fundamental studies of the properties of oil have resulted in the development of improved types of insulating oil. Apart from the usual measurements (permittivity, power factor, viscosity index, insulation resistance, electrical strength, acidity, water content, thermal conductivity, and so on) the molecular constitution of an oil is studied by means of ultra-violet and infra red spectrometry.

Mineral oil is a complex mixture of different hydrocarbons, which can be divided into three main groups, paraffinic, naphthenic and aromatic. The composition of the oil depends on its natural source and on its method of refinement. By the ultra-violet and infra-red spectograms just mentioned it is possible to determine the relative proportions of the paraffins, naphthenes, and aromatics, and also the detail structure within these groups.

A thorough investigation has been made of the evolution and absorption of gas by oils, when subjected to high electrical stresses. The "gassing" qualities of an oil have an important influence on its behaviour as a capacitor impregnant, and it is hence essential to have a quantitative measure of this property. The evolution or absorption of gas, with the oil under electric stress is measured by means of the "gassing cell".

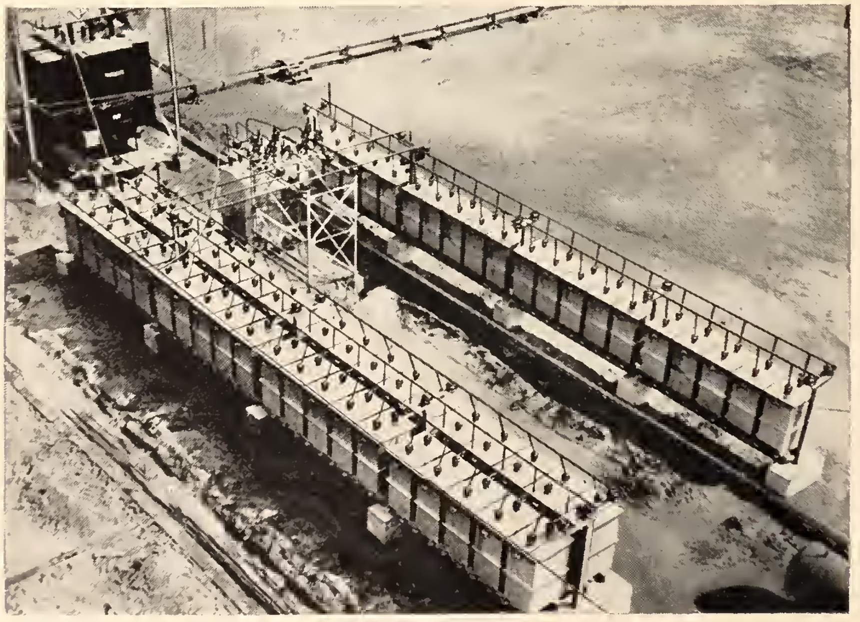
It has been found that as the aromatic content of an oil is increased, its tendency to evolve gas is reduced. On the other hand, as the aromatic content is increased, the oil becomes more susceptible to degradation by heat and electric stress. By adjustment of the aromatic content combined with the addition of appropriate anti-oxidants, it is, however, possible to constitute an impregnant in which both properties are satisfactory.

Other Impregnants

Similar work is in progress on the chlorinated diphenyl impregnants (Aroclors). Since the decomposition products of these materials are toxic and acidic, and hence can corrode the capacitor electrodes, leads and cases, care is required in their utilisation if the high reliability and long service life achieved with oil impregnants is to be maintained. The one attractive feature of chlorinated diphenyl, compared with oil, petroleum jelly or other non-polar impregnants is its relatively high permittivity, which enables the size of the basic capacitor to be reduced by a factor of about 40% or more. The increased permittivity is due to the polar nature of the chlorinated diphenyl molecules, and this results in increased power factor, relatively large variations in capacitance with temperature, and reduced insulation resistance, compared with mineral oil.

Other high-permittivity polar impregnants employed or studied as alternatives to the chlorinated diphenyls include castor oil, fluorinated aromatic compounds and the organic amines.

Fig. 1 Aerial view of the 15,000 kvar. power capacitor bank installed at Sorel, Que.



Ionisation Studies

A major factor determining the ultimate breakdown under stress of an impregnated capacitor is the ionisation discharge occurring in gaseous "voids" in the dielectric. During the last few years, extensive studies have been made of ionisation phenomena, and other long-term deterioration effects, in paper capacitors.

It is found that a significant parameter is the point at which discharge is first observed as the voltage is raised (the discharge inception voltage). Related to this is the discharge extinction voltage, at which discharge ceases when the voltage is lowered. For studies of dielectrics electrically stressed over long periods, the latter is measured, but this would be prohibitively tedious and wasteful if carried out manually. Hence a servo-mechanism has been developed which automatically lowers the test voltage every five minutes to the value at which discharges cease, and then raises the voltage again to the test level. The envelope of the downward-going spikes thus shows the variation of discharge extinction voltage with time of application of stress. The interpretation of such records provides valuable information about the behaviour of discharges in all types of dielectric.

Impregnated Paper Capacitor Design

The results obtained in these researches on paper and impregnants, together with changes in the internal design arrangements, have enabled remarkable reductions in the size and weight of power capacitors to be achieved within recent years. For oil impregnated capacitors over the range of from 3 kvar. to 90 kvar. the volume for a given capacitance has been reduced from an average figure of 275 cu. ins. kvar. to 120 cu. ins. kvar. Over the same range the weight has been reduced from an average figure of 14 lb./kvar. to 6 lb. kvar.

Another design development is the high voltage unit capacitor. These units are normally built for a standard voltage of 2.4 kv. with a capacity of 25 kvar. These units are then arranged in a bank, with series parallel connections to give any combination of voltage or kvar. which may be required.

Corresponding developments have occurred in the design of the smaller impregnated paper capacitors, commonly used in electronic circuits. Such capacitors can be enclosed in aluminum cans or in protective plastic cases.

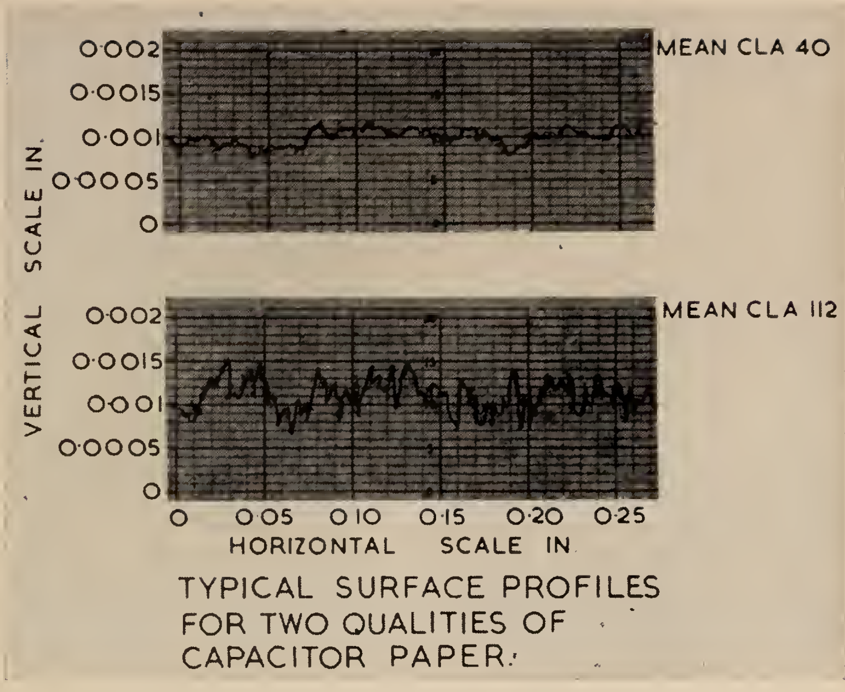


Fig. 2 Typical surface profiles for two qualities of capacitor paper.

SYNTHETIC POLYMER FILMS

Several of the various types of synthetic polymer films developed over the last decade possess attractive features as capacitor dielectrics, particularly for radio capacitors, where material costs are less significant than with large power capacitor banks. Some of the properties of the more important polymer films are listed in Table 1.

Apart from the electrical properties, the two most important properties determining the suitability of a polymer as a capacitor dielectric are its softening temperature, and the minimum thickness in which the film is available in continuous lengths, suitable for capacitor winding.

Polystyrene

Polystyrene is an excellent low loss dielectric available in high quality uniform film. With polystyrene and other synthetic films molecular orientation can be induced by stretching the film to upwards of 50% more than its original length. When released the film does not return to its original dimensions, but remains "set" in its extended length, with the molecules oriented and lying along the direction of extension. The film remains in this stretched and oriented state until it is heated to slightly above the softening temperature. Dis-orientation then takes place and it returns to its original length.

This property of orientation is utilised in the winding of polystyrene and other synthetic film capacitors. The winding is carried out with the polystyrene in the oriented state. After this the winding is "heat-shrunk" by heating it to just above the softening temperature. The film then contracts, thus producing a tightening of the winding of the film and stabilisation of the capacitance. Well-constructed polystyrene film capacitors compare very favourably in performance and cost with silvered mica capacitors. The rather low softening temperature limits their use to temperatures up to 70°C.

Polystyrene film capacitors possess the property of holding their electric charge to a phenomenally high degree. A group of three standard 1µF polystyrene capacitors charged to a potential of 500 V, and then kept in a sealed container, have been found at the present time, after six years, to retain more than 85% of their original charge.

Polyethylene

Polyethylene film is comparable in price with capacitor paper tissue, but it is not available in Britain in a thickness less than 18 micron (0.75 mil). It is only, therefore, attractive for high voltage capacitors.

Irradiation of polyethylene by high voltage electrons causes cross-linking of the polymer chains, resulting in improved electrical and mechanical properties at elevated temperatures. While normal polyethylene is only suitable for use at temperatures up to 80°C, irradiated polyethylene can be operated up to 120°C, and, if oxygen is excluded up to 150°C or above.

Electron irradiation is carried out by means of a two million volt particle accelerator of the *Van de Graaff* type. Irradiation of polyethylene causes luminescence.

Terylene

Polyethylene terephthalate (Terylene) film sold commercially as *Melinex* or *Mylar*, is very attractive as an alternative capacitor dielectric to paper, in all respects except cost. It has a high electrical and mechanical strength, a relatively high softening temperature, and it is available in thicknesses down to 6µ (0.25 mil). A 500 V Melinex film capacitor is about equal in size to a 300 V paper capacitor.

Teflon

Polytetrafluoroethylene (P.T.F.E. or *Teflon*) has excellent dielectric properties combined with a high

Table 1. Synthetic Polymer Films

Material	*Permittivity (1 K c/s)*	*Loss Tan. (1 K c/s)*	*Max. Safe Operating Temp.(°C)*	*Minimum Thickness (Microns)**	*Dielectric Strength (Volts/Mil)†*
Polystyrene	2.55	0.0002	70	10	1500
Polyethylene	2.3	0.0003	80	18	1500
Irradiated Polyethylene	2.3	0.0003	120	18	1500
Terylene	3.1	0.005	160	6	6000
Teflon	2.0	0.0002	200	6	1000

*1 Micron = 10^{-3} mm = 0.04 Mil † For Min. Thickness softening temperature, and it is hence suitable for high temperature, low loss capacitors. The material is originally made as a latex suspension, and a special technique has been developed for preparing uniform thin films. The P.T.F.E. latex is dip-coated on to a thin aluminum foil in a film whose thickness is controlled by surface tension and the coating is subsequently heat-treated and sintered by passing through an electric furnace. Laboratory apparatus used for this work is shown in Fig 3. This results in a uniform P.T.F.E. film of thickness down to 6μ (depending on the coating speed and conditions), deposited on the aluminum foil, from which it may be subsequently stripped if required. The slide shows reels of P.T.F.E. film made by the process. P.T.F.E. film capacitors are now available commercially, particularly to meet stringent Service requirements for guided missiles, etc., including an operating temperature of 200°C.

METALLISED CAPACITORS

The capacitors considered so far all have solid aluminum foil electrodes. Because of the presence of pin-holes, conducting particles, or other weak spots in the dielectric tissue or film, it is essential to use two or more thicknesses of dielectric film to eliminate local breakdown. As there are mechanical limitations on the minimum tissue and film thicknesses available, this means that it is often necessary to use a thicker dielectric than is needed to withstand the electrical stress over the bulk of the material. The capacitance per unit volume is proportional to the inverse square of the dielectric thickness, so that the physical size of a capacitor of a given value can be reduced by a factor of 4, by using only one thickness of dielectric film instead of two. This can only be achieved by introducing some method to eliminate the weak spots in the insulating film.

The metallised capacitor construction provides such a method. The solid foil electrode is replaced by a thin layer of metal, deposited by vacuum evaporation or other means. A pair of single metallised dielectric films are wound together to form the capacitor, the electrode connections to alternate layers of metallising being made by spraying on to the ends, and soldering on terminals. After winding and heat treatment (if required), and prior to service, the capacitor is subjected to a gradually increasing d-c. voltage. This causes local breakdown at any weak spots in the dielectric, but the energy of the local internal coronae is sufficient to evaporate and oxidise the thin metal layer in its vicinity, thus terminating the breakdown. After clearing, the capacitor is conservatively rated at a working voltage of one half of the maximum clearing voltage applied. Should any further faults develop in service, these will be similarly cleared by the operating voltage, so that the electrical failure is virtually eliminated by the "self-healing" property of the capacitor.

Vacuum Metallisation

A great deal of research and development work has been carried out on the metallisation of paper and of various polymer films. Vacuum metallisation plant used for this work is illustrated in Fig. 4.

In vacuum metallisation the basic principle is to melt the metal in a vacuum which is hard enough (about 10^{-4} mm. Hg) so that the mean free path of the atoms evaporated from the molten surface is sufficient to carry the atoms on to the paper or film where they are deposited and adhere. The film is metallised continuously. It passes from the supply spool, over rollers to the first crucible, where a very thin monatomic layer of silver is evaporated on to it. (Fig. 5). This forms a sensitising layer for the subsequent evaporation of the main metallised layer from the second crucible. In the initial work zinc and cadmium, which have relatively low boiling points, were used, but more recently techniques have been developed for the continuous evaporation of aluminum directly on to lacquered paper or film. Aluminum is preferable, since it is less chemically active, while its oxide, formed during the "clearing process", has excellent dielectric properties in its own right. After applying the metallised layer, the film passes over a pair of metal rollers, and the resistance square of the metal film is measured between these. This specific resistance is monitored, and it is maintained at a uniform value regulating the speed of the motor driving the film across the evaporation crucible. The film is then wound on the "take-up" spool, contact rollers being used in handling thin films liable to crease or be frictionally electrified.

The vacuum metallisation technique has been successfully applied

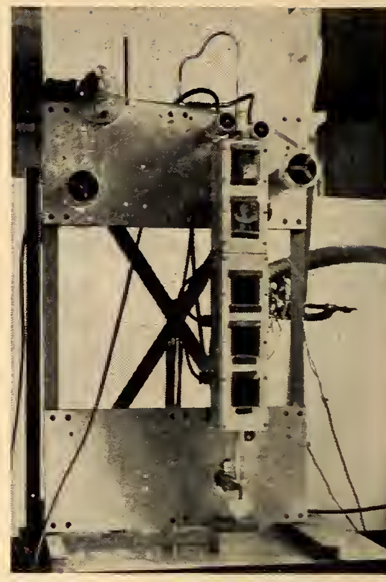


Fig. 3 Apparatus for P.T.F.E. latex dip-coating of thin aluminum foil.

to paper, polystyrene, polyethylene, Terylene and P.T.F.E. With paper a thin layer of lacquer is applied before metallising, to prevent penetration of the metal vapour into the pores. Provided the evaporation conditions are properly controlled, no difficulty is experienced with thermo-plastics such as polystyrene and polyethylene, although the temperature of the metal vapour (1400°C for aluminum) is greatly in excess of the softening temperature of the plastic. A cold water jacket in contact with the top surface of the plastic film assists in eliminating damage to the film by the hot vapour.

Metallised Capacitors for D.C.

Metallised capacitors are particularly suitable for D.C. application in radio circuits. They are not suitable for frequencies above 50kc, since the resistance of the metallised layer and the spray connections then contribute appreciably to the loss factor of the capacitor.

Metallised paper capacitors, of the same capacity and working voltage as conventional capacitors, are smaller in size due to the type of construction. This is again apparent when one compares metallised capacitors made from plastic films of various thicknesses, with a silvered mica capacitor.

Metallised Capacitors for A.C.

Although metallised capacitors were originally developed for d-c. applications in radio circuits, they have attractive potentialities for a-c. power capacitors, and these are being actively studied. Any doubts about the "self-healing" properties of metallised paper capacitors under a-c. conditions were completely resolved by a rather spectacular experiment. A metallised paper capacitor winding of 18μF, was connected to a 400V, 50c/s supply, in series with a current meter and fuse. While on voltage a steel nail is driven through the capacitor winding. Due to the rapidity of the "clearing" action no change could be observed in the meter reading, either during or after the insertion of the nail, and the capacitor continued to function satisfactorily. It should therefore be possible to develop metallised paper capacitors for a-c. applications, equivalent in performance and life to normal impregnated paper capacitors, but considerably reduced in physical size.

CERAMIC CAPACITORS

The Ferroelectrics—Barium Titanate

The high permittivity of ceramics, based on the ferro-electric material, barium titanate, form an important group of dielectric materials for use particularly in miniature radio capacitors.

Barium titanate is a ferro-electric material, in which the molecular dipoles are aligned in domains, just as in a ferro-magnetic material the molecular magnets are aligned in domains. Such domains impart a high permeability to a ferro-magnetic material; in a ferro-electric material they produce a high permittivity.

There are several similarities between the dielectric behaviour of a ferro-electric substance and the magnetic behaviour of a ferro-magnetic substance. Thus the permittivity of pure barium titanate is about 1500 at normal temperatures, rising to about 7000 at 120°C. Above this so-called *Curie* temperature, the material loses its ferro-electricity, since the domain structure is destroyed by thermal vibrations, and the permittivity falls rapidly with increase in temperature. A similar effect occurs with a ferro magnetic material, which loses its high permeability when heated above its *Curie* temperature.

High Permittivity Ceramics

For some capacitor applications, the permittivity-temperature characteristic of barium titanate, with a practically constant value of 1500 at normal temperatures is adequate.

Higher permittivities, and hence larger capacitance/unit volume, can be obtained by shifting the high permittivity region near the *Curie* point to the normal temperature region. This can be achieved by the addition of other titanates, notably strontium titanate, to the barium titanates, forming mixed titanates whose *Curie* point lies at lower temperatures.

These characteristics are too sharply peaked for most capacitor applications. The characteristic can however be flattened by suitable additions, notably the stannates and the zirconates to the titanate ceramics.

High-Permittivity Ceramic Capacitors

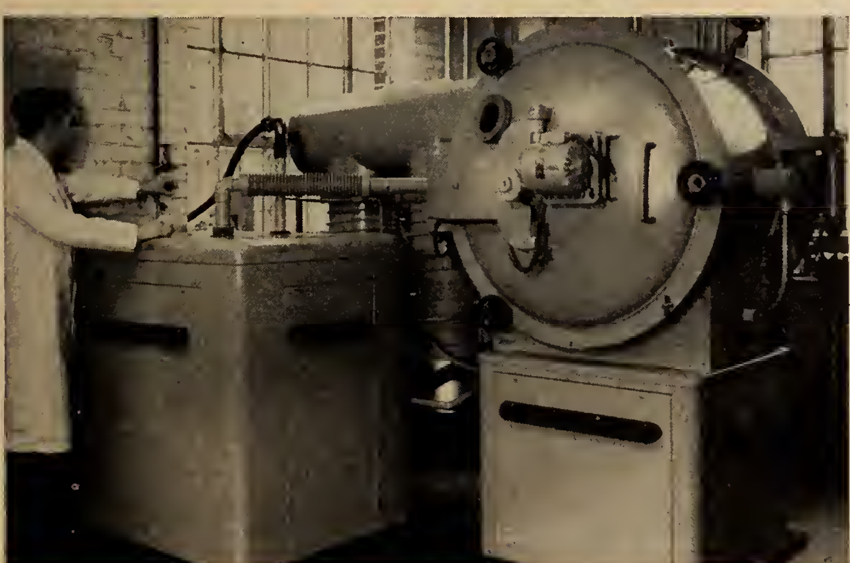
Due to the high permittivity, a large capacitance/unit volume is achieved with low voltage miniature ceramic capacitors. These ceramic capacitors are particularly suitable for use in h.f. radio circuits, when low loss and high stability of capacitance are not essential. More than 40% of all capacitors used are ceramic types.

Although most ceramic capacitors operate at relatively low voltages, a special high-density high-permittivity ceramic, with a breakdown strength of over 80 kv./cm. has been developed for high voltage applications. An experimental 5500 pF ceramic capacitor was designed to operate at 25 kv., and tested up to 80 kv. without failure, with the equivalent impregnated paper capacitor which it replaces. The ceramic disc is embedded in epoxy resin to eliminate surface tracking, and it is held in a protective cup of phenolic resin.

Other Ceramic Capacitors

Apart from the high-permittivity titanate ceramics, ceramics based on titanium oxide (rutile) and magnesium titanate/barium titanate mixtures, which have permittivities of about 90 and 36 respectively, form an important class of capacitor dielectrics. Being non-ferro electric, these materials have a low dielectric loss. They are particularly suitable for use in high-frequency capacitors, either at low voltages in radio receiver and similar circuits, or at high voltages in transmitters or other high frequency power applications.

Fig. 4 Plant for vacuum metallisation of paper and polymer films.



ELECTROLYTIC CAPACITORS

Like the oil-impregnated capacitor, the aluminum electrolytic capacitor has maintained its traditional place in the components field. During the last decade substantial improvements in design and technique have, however, been made, and the reliability and performance of the modern aluminum electrolytic capacitor are greatly in advance of its pre-war counterpart.

Aluminum Electrolytics

Research has been carried out on the various phases of aluminum electrolytic capacitor fabrication. In the manufacture of electrolytic capacitors the surface of the aluminum is often first etched. This is because the effective surface area on which the capacitance depends, of the rough surface, due to the hills and valleys, is greater than that of the polished surface. One of the most significant advances has been the development of an improved method of etching, called "ripple etching", producing additional increase in the capacitance/unit area of the formed foil. In ripple etching an alternating current is superimposed on the normal direct current used for the etching. By suitable control of the a-c./d-c. ratio and of the a-c. frequency, capacitance magnifications of up to 12 times at a forming voltage of 500 v. and correspondingly increased magnifications at lower forming voltages are achieved.

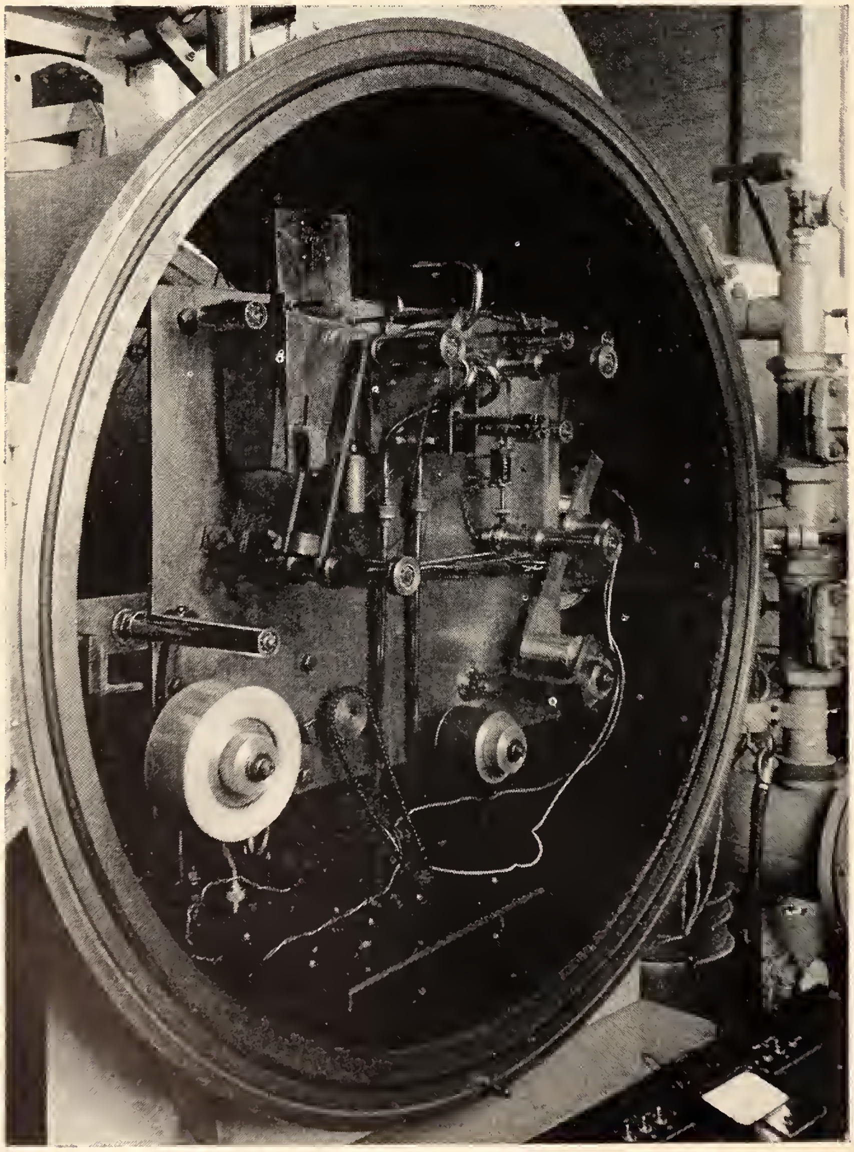
A range of miniature aluminum electrolytic capacitors, has been developed for use at low voltage in transistor circuits. Also, a group of special high-grade aluminum electrolytics, known as *Superlytics*, incorporating the results of recent researches, have an electrical performance and insulation resistance comparable with impregnated paper capacitors.

Tantalum Electrolytics

The post-war availability of tantalum has led to the development of the tantalum electrolytic capacitor. Tantalum and its oxide are much more chemically inert than aluminum and its oxide, and tantalum electrolytic capacitors have improved electrical performance and life compared with aluminum electrolytics.

It has been found that a major improvement in the uniformity and stability of the capacitor is produced by electro-polishing the tantalum foil prior to formation.

Fig. 5 Internal view of vacuum metallisation plant.



CAPACITORS FOR PRINTED CIRCUITS

One of the most important recent developments in the electronic industry has been the introduction of printed wiring circuits. These printed circuits, etched from the copper foil and supported by an insulating base material, can be mass-produced, and they lend themselves readily to mechanised methods of circuit assembly. A wide range of capacitors have been developed specifically for use in printed circuits.

MINIATURE CAPACITORS FOR TRANSISTOR APPLICATIONS

The metallised capacitor, the high permittivity ceramic capacitor, and the electrolytic capacitor, each represent techniques for the miniaturisation of components, by increasing the capacitance/unit volume. The development of transistors, as alternatives to electronic valves, has intensified the demand for miniature capacitors operating at low voltages of 5-50 v. The satisfaction of this demand involves ingenious new techniques in capacitor design.

Metallised Lacquered Foil Capacitors

The metallised lacquered foil capactitor represents a further stage in the miniaturisation of the metallic plastic film capacitor. The construction consists of a 6 micron aluminum foil, each side of which is coated with a thin lacquer of dielectric, from 1 to 6 micron thick. One edge (A) of the aluminum foil is then etched back 1-2 mm. by immersion of the rolled foil in a hydrofluoric acid solution. The thin lacquer layers on each side of the foil adhere to each other after the etching, thereby insulating the edge of the foil. One of the dielectric coatings is then metallised by vacuum evaporation, leaving the unusual insulating margin along the other edge (B). The coated metal foil, is then wound in a single roll to form a capacitor. Electrical connection is made to the metallised electrode along edge (A) by metal spraying and soldering. Similar connection is made to the aluminum foil electrode along edge (B), using ultrasonic soldering for connection to the aluminum. The capacitor is then "cleared" electrically, to eliminate any weak spots in the insulation, by the application of a gradually increasing

Table 2. Capacitor Types and Properties

	Loss	Voltage	*Max. Freq.*	*Max. Temp. °C*	*Size μf*	*Cost*	*Status*	*Principal Applications*
CONVENTIONAL								
1. Paper/Oil	M	M.H.	A.C.	100	M (1)	L	P	P.F. Corr. Energy Storage
2. Paper/Aroclor	M	M.H.	A.C.	100	M (<1)	L	P	Radio, Etc.
3. Polystyrene	L	M	H.F.	70	M (<1)	M	P	H.F. Filters
4. Irradiated Polythene	L	H	H.F.	120	M (<1)	L	D	H.V. High Temp.
5. Terylene	M	M	A.C.	140	M (<1)	M	D	Radio Circuits
6. Teflon	L	M	H.F.	200	M (<1)	H	P	High Temp. Guided Missiles
CERAMICS								
7. High-K-Titanates	M	L.H.	A.C.	100	V.S.	M	P	Radio Min. H.V.
8. Rutiles, Etc.	L	M.H.	H.F.	200	M (<1)	M	P	R.F. Rec. & Trans.
ELECTROLYTICS								
9. Aluminum	M	L.M.	A.C.	85	V.S.	L	P	Radio Transistors
10. Tantalum	M	L.M.	A.C.	85	V.S.	M	P	Energy Storage
METALLISED								
11. Paper	M	M.H.	A.C.	100	S	L	P	D.C. P.F. Corr.
12. Polystyrene	L	M	A.C.	70	S	M	P	D.C. L.F. Filters
13. Terylene	M	M	A.C.	140	S	M	D	D.C. Radio
14. Teflon	L	M	A.C.	200	S	H	D	High Temp. L.F.
MINIATURES								
15. Met. Lacquered Foil	L	L	A.C.	70-200	V.S.	M	D	Transistor
16. Met. Alum. Oxide	M	L	A.C.	200	V.S.	M	D	Circuits up to 50V
17. Solid Tantalum Oxide	M	L	A.C.	150	V.S.	H	D	

L = Low M = Med. H = High S = Small V.S. = Very Small P = Prod. D = Dev.

d-c. voltage up to twice the working voltage.

The metallised lacquered foil construction is applicable to any dielectric that can be applied as a lacquer to the aluminum foil. Among the materials successfully used in this manner are Desmodur/Desmophen lacquer polystryrene, polyethlyene and polytetrafluoroethylene.

A related miniature capacitor development is the metallised aluminum oxide capacitor developed from the electrolytic capacitor. In this type, the dielectric consists of a thin (0.5 to 1μ) layer of dry aluminum oxide, formed electrolytically. A metallised layer is evaporated on to the oxide surface, forming a capacitor with the very high capacitance of about 0.1μF/sq. in. The electrical properties of the metallised aluminum oxide capacitor may be used either in flat film, wound or stacked form.

Solid Tantalum Oxide Capacitor

The most recent miniature capacitor development is the solid tantalum oxide capacitor. This type has been evolved from the sintered tantalum electrolytic capacitor, which consists of a formed, porous block of tantalum, coated with oxide, and used with a sulphuric acid electrolyte. The corrosive nature of this electrolyte is a disadvantage of this type of capacitor.

In the new development, the formed porous tantalum block is immersed in a manganese nitrate solution, which is heated and thus decomposed, depositing semi-conducting manganese dioxide in the pores of the body. The surface of the block is coated with graphite, sprayed with metal, and a soldered lead attached as the cathode terminal.

The solid tantalum oxide capacitor has the highest capacitance/unit volume of any type (up to 10,000μF/cu. in. at 5 v. d-c.), yet its electrical performance is superior to electrolytic or other comparable capacitors, for potentials up to 35 v.

CONCLUSIONS

The sections of this paper reveal something of the multiplicity of types of capacitors that have been developed to meet diverse requirements and applications.

To summarise and present a clearer picture of the whole situation, Table 2 sets out the main features and properties of the 17 types of capacitors mentioned in this paper. It will be noted that of the 17 types considered, 10 are in large-scale commercial production. The remaining 7 which are still under development, are designed to replace or to supplement existing types, or to meet new and more stringent requirements.

Each new application or requirement as it arises is a challenge to the capacitor scientist and engineer. Progress over a wide field is rapid and there is little doubt that the future needs of the great electrical and electronic industries will be met.

MEASURING HUMAN MOTIONS for DESIGNING MACHINES

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FIFTEEN YEARS have seen overwhelming changes in engineering. The technology has improved, scientific frontiers have been pushed forward, new principles and concepts have emerged and of equal importance, the engineer has become aware of and started to assume responsibilities for the human being.

This awareness represents a significant stride forward for the professional stature of engineering. It is now considered necessary to attempt to fit the surroundings and equipment to the human being. It is difficult to state from where this new trend has come, but certainly new information from psychology and physiology has helped much. Social awareness of human values has become prevalent in executive thinking. In addition, labor unions have helped focus attention on the human being. Regardless of the source, everyone agrees that this awareness is a good step, and should even be expanded.

Of the many activities important in engineering, one concerning design is related to this awareness: the design of machines and equipment to fit the human being. Western civilization is known for its ability to design equipment for extremely advanced functions and performances. However, some of these designs have been literal monsters in relation to the human use of the equipment.

Part of the reason this condition has existed is related to the lack of information available to help the machine designer in his work. The most important unsolved problem is to determine what happens in the performance of work. This question should be answered for uses in the general and specific senses: (1) identifying and formulating general principles, and (2) attempting to test and/or evaluate specific designs of machines or equipment. There have been some general principles and specific techniques available in the field of industrial engineering. These have been rather broad and gross, not providing the type of information really required as indicated above.

This is a serious engineering problem and affects the general tendency of engineers to be more conscious of the human problem. This problem is one for which engineers and engineering principles are needed for arriving at a reasonable solution.

Fundamentally, the question of determining the performance of an individual using a particular piece of equipment is the same as asking what are the individual's motions at that particular design. Most research tools, like kymograph, motion pictures, and chronocyclegraph, have resulted in little additional information for the machine designer. The problem then becomes one of measuring the motions to provide enough information for the engineer to fit the classical definition of work, concerning the motion of a point of application of a force.

In effect, this means that the velocity, acceleration, deceleration, position in space, distance and time of a motion must be measured. It has not been possible to measure these factors for human motions until the UNOPAR (Universal Operator Performance Analyzer and Recorder) was developed. With the above information, it will be possible to obtain all information about what happens in the performance of any motion or series of motions.

Development of UNOPAR

In designing a new device for making these measurements, certain factors had to be considered. The measurements must be three dimensional; any attachments to the body member studied must be small and light; any device developed must be capable of being used under actual working conditions; the range of velocities might be rather small (0 to 10 feet per second); the range of acceleration and deceleration could be quite large; and so forth. By exploring the application of electronics in this problem, a suitable solution, the UNOPAR, has been obtained.[1]

Initially, there were a number of possible measuring techniques which could conceivably fulfill some or a great number of the aforementioned requirements. After careful consideration, it was decided that the Doppler effect with sound as the radiation medium presented the fewest formidable obstacles for successful development of a work measuring device.

Fundamentals of the UNOPAR

The operating frequency of the UNOPAR was chosen at 20,000 cycles per second which is above the threshold of hearing at normal levels of intensity. This frequency helps overcome the interference problem from other noises within a factory or laboratory and would not disturb the performance of the operator. The sound emitting source (speaker) must be attached to the body member (wrist, finger, elbow, etc.) which is to

1. J. Goldman, "Development and Testing of an Electronic Method for Determining Acceleration, Constant Velocity and Deceleration of Body Motions," Doctor of Science Dissertation, Washington University, St. Louis, Mo., Aug. 1955.

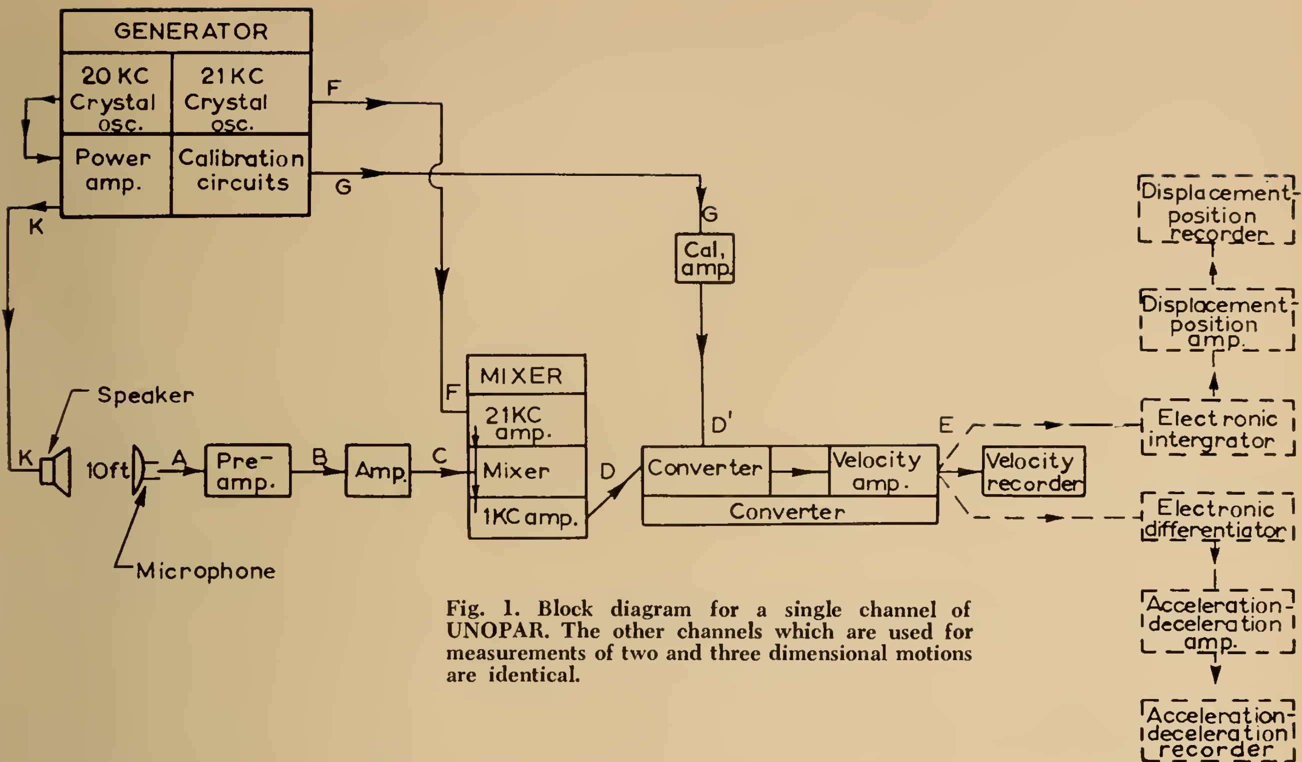


Fig. 1. Block diagram for a single channel of UNOPAR. The other channels which are used for measurements of two and three dimensional motions are identical.

be studied; however the size of this source is at present smaller in diameter, thinner and lighter than an ordinary wrist-watch.

Three microphones, oriented in three planes, with the directional axis of each perpendicular to the directional axes of the others, are utilized to measure motions in the three planes. Each microphone receives its component portion of the sound waves emitted from the speaker attached to the body member moving towards or away from the microphone. This system provides a variable reference orientation, since the three microphones can be rotated in any position as long as their orientation with respect to each other is fixed. This flexibility makes it possible to circumvent obstacles to the path of transmission and to permit use of overhead space in industrial situations.

Because of the Doppler effect, a transmitted source of sound (speaker) that is in motion relative to a stationary receiver (microphone) provides an increase or decrease in frequency of sound waves at the receiver which varies directly with the velocity of the source. Motions toward the microphone will increase the frequency received, and motions away will decrease the frequency received.

Fig. 2. The new specially designed Lorenz Electrostatic Speaker is only 1" in diameter, ¼" in thickness and weighs less than one ounce. It is shown with a regular watchband and the two small wires used to operate it. The UNOPAR speaker is being worn on the wrist of the operator being studied.

To minimize the error which can be caused by the moving speaker not remaining in the direct axis of each stationary microphone, the motion of the speaker is assumed to be confined within a one yard cube and the microphones are placed 10 feet away from the centre of this cube. The maximum possible error of measuring the velocity and time (the two basic measurements made with UNOPAR; the other measurements are made mathematically and electronically treating the two basic measures) will not exceed 1% of true value. Because (1) almost all work activity is usually performed with a one yard cube, (2) the size of the cube and the distance of the microphones from the cube can be increased (with the appropriate adjustments in UNOPAR) if desired, and (3) it is possible to orient this cube in any manner to encompass the motions in an operation, this error problem becomes virtually non-existent for practical purposes.

Operation of the UNOPAR

The basic operating procedure of the UNOPAR begins with the generation of the operating frequency of 20,000 cycles per second (by crystal controlled oscillator at 20.000 k.c.). As is indicated in the block diagram (Fig. 1) this 20 kc. signal is sent through a power amplifier to the speaker. Most of the research work performed to date has been done by moving a speaker rather than by attaching a speaker to a moving body member. This has helped in learning more thoroughly about the potentialities of UNOPAR. In the near future actual body motion tests will be performed. If more than one body member is to be studied, a different frequency signal would be used for each member involved.

At the present time the Lorenz electrostatic speaker (Fig. 2) is being utilized in the experimental work. Present speaker developments indicate the actual size of the speaker will be reduced to the size of a thick nickel or quarter. This size will make it possible to study any type of physical work, because the speaker will not hinder the operator in any way.

The perpendicular vectors of the frequency changes are received by the three microphones. The block diagram (Fig. 1) shows only one microphone and its corresponding circuit; the same circuity would be used for the other two microphones. When the speaker is in motion, the frequency of the sound received at the microphone will be 20 kc. per second plus or minus the Doppler difference caused by the motion of the speaker. Since the voltage level of the received signal is low (175 micro-volts), it is sent through a preamplifier attached to the microphone stand (Fig. 3). From here, the signal is sent to an amplifier section of the UNOPAR electronic relay rack. This amplifier has seven tuned amplifier stages.

The 20 kc. signal, plus or minus the Doppler difference frequency, is mixed with a 21 kc. reference signal (generated by a crystal controlled oscillator of 21.000 kc. control). From this mixing, a 1 kc. signal, plus or minus the Doppler difference frequency, is obtained. This is the usable signal for conversion to voltage. It is sent through two tuned amplifier stages to the converter chassis.

The converter circuit is arranged to provide a d-c. voltage output directly proportional to the frequency of the input signal. The resultant d-c. voltage is therefore directly proportional to the velocity of the speaker.

The d-c. voltage for each plane of motion is sent through an amplifier to the three velocity recorders. Each amplified d-c. voltage is also sent to an electronic differentiator, whose output voltage is proportional to the acceleration and deceleration of the speaker. Each of these signals is sent to an acceleration-deceleration recorder. Each amplified *velocity* voltage is also sent to an electronic intergrator whose output voltage is proportional to the displacement of the speaker. Each of these signals is sent to a displacement-position recorder. Direction of the motion is determined from the voltage variations above or below the voltage output of the one kc. zero velocity signal input. A larger voltage indicates a motion toward the microphone, and a smaller voltage indicates a motion away from the microphone. The three records for a given measurement unit can be combined into an absolute total by electronic vector summation.

The calibration circuit is designed to generate sine wave signals of the proper frequency and voltage to check the velocity and acceleration maximum displacement values, and the zero adjustment of all of the electronic equipment.

Fig. 3. Dr. Goldman makes the final alignment of the Altec-Lansing high frequency microphone in preparation for making a measurement with the UNOPAR. The self-contained preamplifier unit is attached to the microphone stand.

A 12 channel d-c. oscillographic recorder is used to plot the individual vectors of velocity, acceleration-deceleration, and displacement-position. The summation vectors of velocity, acceleration-deceleration, and displacement-position are also plotted on this recorder. The recorder is capable of plotting information at a constant synchronously controlled maximum speed of 125 mm. per second (5 inches per second), thus providing an accurate timing record for every motion and the above information.

Future Development of the UNOPAR equipment

The present electronic equipment and recorders are fairly large. De-

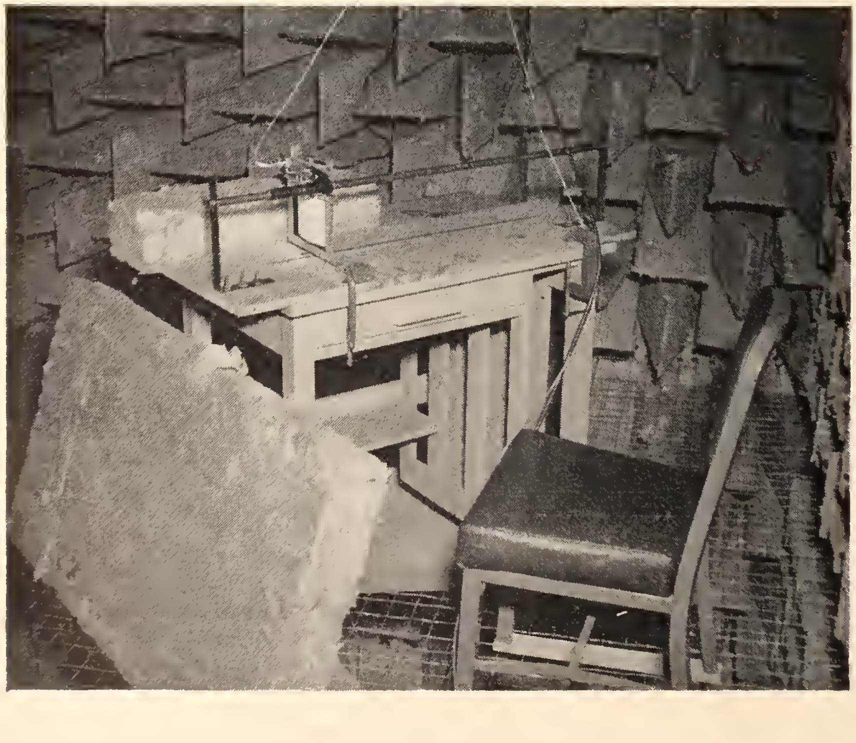


Fig. 4. Original verification apparatus used to check the validity and accuracy of the UNOPAR measurements. Note the small accelerometer (connected to the black wire) firmly attached to the same rigid frame as the test speaker, to insure that motions of the speaker and accelerometer were identical. Entire test apparatus is shown inside the anechoic chamber where the validification tests were made.

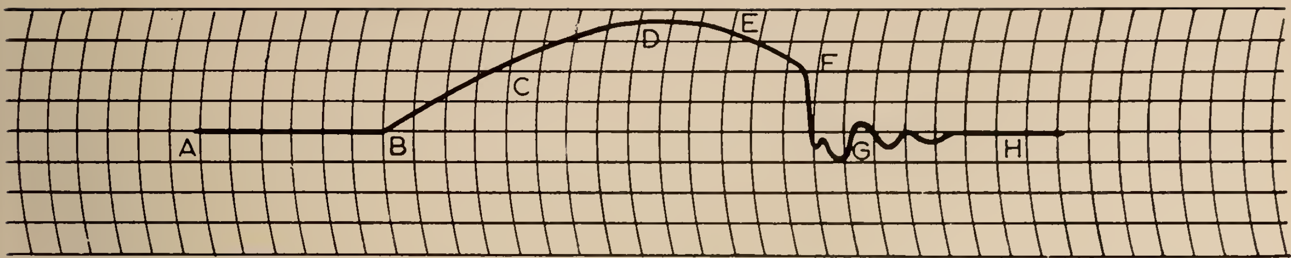


Fig. 5. Facsimile of a section of the UNOPAR velocity vs. time tape on which is recorded the one plane motion of the original test speaker. In this motion the hand moves the speaker from rest, over a known distance and strikes the front end brace of the test apparatus (Figure 4) to check the transient response of the system. The straight line section of the tape between points A and B shows zero velocity (center line of chart is zero) indicating the hand at rest. As the hand began to move the speaker down the rod, the velocity charted increased rapidly from point B to C to D. The changing velocity along this section of the curve (slope) is the acceleration portion of the motion. At point D, the velocity reaches its peak. The curve is not flat (does not remain at a constant velocity) on top but changes smoothly from its rising characteristic (acceleration) to a falling one (deceleration) as the hand begins to slow down (D, E, and F) before striking the end support. The speaker struck the barrier at point F and the velocity dropped immediately. Slight rebounds (damping) of the hand and speaker frame are indicated by the wavy motions of the curve at Point G. The straight line at point H indicates that the hand had come to rest again. This motion was recorded with the tape running at the fastest speed of 125 mm./sec. Therefore, each large division between the curvilinear vertical lines on the tape represents a time interval of 0.000665 minutes. The time interval for the performance of this motion is easily and accurately computed.

velopment of the equipment indicates there will be a substantial reduction in the amount, size and weight of the necessary components. At the present time all the electronic equipment must be in operation when measurements are to be made. However, in the near future a 3 channel magnetic tape-recorder will be introduced into the circuit, between the mixer amplifier and the converter chassis. One channel of the tape-recorder will be utilized for each one of the three planes. The inclusion of the tape-recorder makes UNOPAR a much more versatile measuring device, since only a small part of the electronic equipment need be present at the operation when measurements are being made. The tapes can be taken back to an office or laboratory and studied at a later time at the leisure of the analyst. Magnetic tapes provide a simplified and compact system of storing information, a much more practical way of utilizing UNOPAR, and an easy method for referring to any motion for new measurements or repetitions of the measurements.

Another problem to be solved concerns handling, processing, and interpreting the great mass of data provided by the UNOPAR. At the present time, all the information is plotted in graphical oscillographic form. Each motion made by the operator provides data of velocity, acceleration, deceleration, displacement, position, and time. A digital computer would greatly facilitate handling and interpreting these data and performing any mathematical manipulations desired. Since the information from UNOPAR is in analog form (a continuous plot as every motion occurs), a conversion has to be made.

At the present time, the plotted curves are measured visually using a specially developed UNOPAR tape analyzer, and these measurements are punched into a digital computer input card. This requires a great deal of time and effort. To reduce greatly this additional work, the output of the UNOPAR can be fed directly into the analog-to-digital electronic converter. The output information from the converter takes the form of punched cards or magnetic tape suitable for input purposes to the digital computer. This proposed system for data handling is now in the preparation stage.

Reliability of UNOPAR measurements

Tests for the reliability of UNOPAR measurements were made for a one plane motion (there is no criterion for a three plane motion) with an accelerometer as the criterion source. The test-speaker apparatus is shown in Fig. 4. The test was made in an anechoic chamber. This was done to eliminate all extraneous noises and spurious reflections which might interfere with the accuracy of test measurements. The speaker and accelerometer were rigidly mounted on a frame for the one plane motion.

Chi-square and correlation techniques were used to check the size and shape of UNOPAR and accelera-tion-deceleration plots with the similar plots from the criterion accelerometer. Chi-square probabilities of 0.99 and above and correlations of 0.99 and above were obtained, indicating excellent fits for the two sets of curves. Additional verifications were made by calculating the standard deviation for percentage of error from the accelerometer plots for the maximum (peak) velocities, maximum acceleration-deceleration values, and time for a series of motions. For velocity, the standard deviation was 1.08 percent; for acceleration-deceleration, 2.17 percent; for time for velocity, 1.06 percent; and for time from acceleration, 2.79 percent. These results indicate excellent measurements from UNOPAR (there is evidence that indicates part of most of the errors obtained were due to the mass action of the accelerometer, not to UNOPAR).

A sample of the type of information available from UNOPAR is shown in Fig. 5. The motion was performed on the test set-up of Fig 4, and the motion was stopped by the support at the end of the track. The velocity plot in Fig. 5 shows the direct response of the device to a motion of this type. This was a critical test of the transient response of the system since the speaker was brought to zero velocity almost instantaneously. Another illustration of a velocity curve from UNOPAR is shown in Fig. 6. This plot is from a research project currently in progress.

Uses of the UNOPAR

Because the UNOPAR provides the measurements of actual human performance, many uses and benefits can be expected in the industrial situation. Other disciplines which make studies of human being performances will be able to use such a device. A brief review of some of the problems UNOPAR can help solve and the possible uses of the UNOPAR is given below.[2]

2. For a more complete discussion see the following: G. Nadler, **Motion and Time Study**, New York: McGraw-Hill Book Co., 1955, pages 417-428; G. Nadler, "Electronics in Work Measurement," Proceedings, 6th Annual Conference, American Institute of Industrial Engineers, 1955; J. Goldman and G. Nadler, "Electronics for Measuring Human Motions," **Science**, Vol. 24, No. 3226, pages 807-810, October, 1956; J. Goldman, op. cit., page 85.

1. Work Simplification and Measurement. This is an important area in which information valuable to the machine designer would be obtained. Many problems confront the analyst in this area. What is a motion? How is it performed? What are correct classifications of motions? What effect does one motion have on another? What is the sequence of motions? What is the proper method of performing a job? How can an operator's performance be measured? What is the effect of mechanical or difficulty factors on operator's performance?

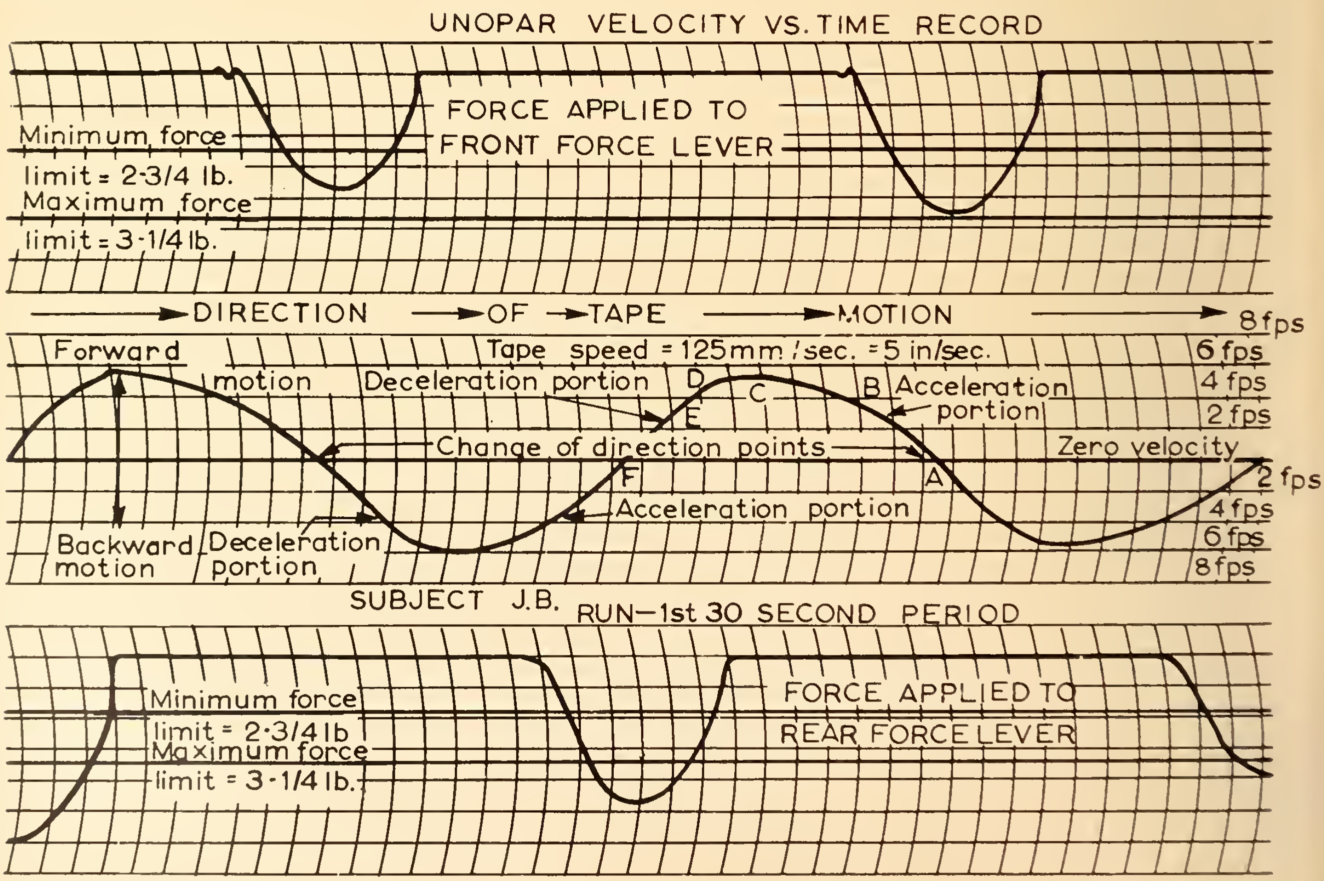
2. What is fatigue? Engineers are accustomed to the word fatigue in relation to materials. Now it has become important to learn about fatigue in relation to human beings to assist in design of equipment. Little is known about this subject, and getting the information about motions that UNOPAR provides will produce further advances in this area.

3. Psychological activities. There are many areas in psychology which will eventually provide information for engineers. Since psychology deals with why people do the things they do, it becomes important to correlate this information with work performance records. Certainly the UNOPAR information on work will be highly valuable for such purposes. In addition, UNOPAR information will be helpful in selecting the right people for the jobs or equipment to be used, and for training them for the work to be done.

4. Physiological activities. Just as in psychology, there will be need for UNOPAR information for physiologists. The physiologists deals with the physical functioning of the body, and of course, this is highly related to the work performance itself. It will be possible for physiologists to learn the relationship between work and the functioning of muscles, heart rates, oxygen consumation, and so forth.

5. Other engineering activities. Materials handling depends on people to move material, drive trucks, operate hoists and push dollies. Automation will depend on information concerning man's abilities and capabilities under nonrepetitive work situations. Production control requires information on scheduling which is dependent on time standards. With UNOPAR delving into

Fig. 6. Facsimile of a section of the UNOPAR tape record taken from a current research project being performed for the Office of Naval Rcsearch. The UNOPAR velocity vs. time record is shown on channel 2 (center) of this tape and a force measurement is shown on channels 1 and 3. This research project was undertaken to study the effects of learning on the performance of a job. The job was one of learning to apply a certain force (within gvien tolerance limits) at both ends of a 19 in. motion. A resume of a typical cycle shows that the motion starts (point A) at the front end of the test table after a force has been applied to a force lever at this end. The subject moves with a rapidly increasing velocity from point A to B and then to the peak velocity at point C where he begins to slow down in anticipation of striking the rear force lever. The jog in the curve (sharp deceleration) at point D indicates that contact with the force lever has been made (see also point D') and subject then decelerates to zero velocity when he thinks that the terminal force has approached the assigned value. An observation of the actual terminal force applied to the rear force lever ,point F") shows that the subject exceeded the upper tolerance limit for this cycle. The subject is signaled that he is within the tolerance force range by a buzzer which sounds whenever a force is within the acceptable limits. The subject then begins the return cycle to the front force lever (from point F).



the fundamental structure of work, many engineering activities will benefit.

6. Other branches of science. Biomechanics is interested in the relationship between man and machine, and much of their work depends on information concerning what an operator does and the time or pace for the performance. Physical education is directly concerned with motions, motion paths and learning more about what an athlete does in his performance. The effects of mental illness on the performance of the job would help find where such persons might be profitably utilized. Physically handicapped persons could also be studied to find information about their usefulness. Military possibilities are many. What is the proper load and distribution of load for a soldier charging across a field? What does a jet pilot do in operating his controls?

This list of possible uses of UNOPAR could be expanded greatly since many applied sciences deal with human beings. A complete understanding of what a person does and how he does it will, when this is needed, greatly contribute to the most effective results in the various disciplines.

Although the UNOPAR has not developed complete information on human performance, it is apparent that this tool will greatly assist the engineer in his functions for the future. Certainly, this tool should make the engineer even more aware of his responsibilities for proper design for human use of equipment.

ECOLE POLYTECHNIQUE

(Continued from page 52)

120,000 volumes can be stored in the shelves.

At the west end of this floor are storage cabinets for maps, and at the opposite end is a secondary reading room which can accommodate 48 persons. In addition there are some thirty well-lit tables along the outer wall at which publications can be consulted.

The two floors of the library are also linked by an electrically-operated elevator.

Classification of Publications

As already mentioned, the main classification of publications is by the universal decimal system, but certain exceptions are made to facilitate reference to particular subjects.

The central reference file has cards for each item by name of author, by title of publication, and by subject. All these are listed alphabetically and, in the case of titles, regardless of the original language of the article. However, the pertinent information is in French.

Dictionaries and similar reference volumes, which are not issued on loan, are kept in separate shelves with adjoining reading tables.

Books are loaned only to teaching staff, students, and graduates of Ecole Polytechnique, with the exception of inter-library loans, but other interested persons are allowed to consult material in the library.

MATERIALS TESTING DEPARTMENT

The study of the mechanical properties of materials at Ecole Polytechnique has been subdivided. The materials testing department studies ferrous and non-ferrous metals and alloys, woods and plastics. Other materials such as concrete, bricks, etc., are the province of the civil engineering department.

The department provides basic introductory studies, postgraduate work, and research work by personnel members, both in the fundamental and applied fields which may lead to improved industrial applications. Many published reports of the work of this department have already made it widely known in North America, France, and Britain. Further advances are anticipated, and the new quarters, which almost double the previous facilities, will be most helpful to that end.

Facilities

The main room in the department contains all the test machines for static and dynamic tension, impact, torsion, and hardness. Extensometers, dynamometers, and precision instruments for mechanical, optical, and electrical measurements are enclosed by glass partitions, together with testing machine accessories and calibration equipment.

A smaller room houses several fatigue-testing machines, most of which were designed and built in the department's workshops. Tests can be made over a wide range of geometry and environment conditions for tension, compression, torsion in uni, bi and triaxial fatigue sollicitation.

High-temperature studies are carried out in other rooms equipped with furnaces and apparatus for analysis and the observation of crystalline structure. A 65 kw. furnace fitted with hydraulic pumps and controls is used for creep studies at high temperatures and pressures on 7 ft. long, 1½ in. wall thickness pressure vessels.

Another room is equipped for photoelasticity measurements, and an important feature is the workshop in which the various test pieces are machined. A photographic darkroom completes the laboratory installations.

A separate concrete room near the laboratory is used for plastic fatigue testing on model pressure vessels, 4 ft. long, ¾ in. wall thickness.

Other Features

A portable crane is provided for handling heavy loads, and a large door allows trucks to enter. All dividing partitions in the laboratory are glazed above a height of three feet from the ground, to give all-round visibility. An insulated double ceiling is provided to prevent the noise of machines reaching the library, which is immediately above the laboratory.

3500 TON UNIVERSITY OF TORONTO BUILDING MOVED 250 FEET

R. M. Bremner, P.Eng., A.M.I.C.E.,
in charge of construction and planning at the University of Toronto.

AN UNUSUAL engineering project was undertaken last summer at the University of Toronto. The building which houses the Faculty of Forestry was moved two hundred and fifty feet to a new foundation. The main reasons for this move were to:

(a) Provide a clear site for an extension to the existing McLennan Laboratories — construction of this extension will be started in the spring of 1959.

With the Forestry building in its old position the extension to the McLennan Laboratories would be 'U' shaped and involve the construction of an additional five hundred feet of external wall. The 'U' shape and other complications made it difficult to plan a satisfactory layout of laboratories and lecture rooms.

(b) Preserve Baldwin House.

A 'U' extension would necessitate the demolition of one of Toronto's oldest and finest residences. Until acquired by the University in 1923, Baldwin House was the residence of Ontario's Lieutenant Governors.

(c) Extend the facilities of the Department of Forestry.

The increased enrolment of students and the demand for better post graduate courses had taxed existing facilities. An extension was required to the existing building but no space was available as a result of the plans for the McLennan Laboratories.

(d) Maintain facilities for 1958-1959 classes.

Construction of a new Forestry building would take about eighteen months and for this period Forestry facilities would be disrupted; the University did not relish this delay and inconvenience. The estimated cost of new construction was $600,000.—a factor which was also given much consideration.

Tenders were called, at the beginning of May 1958, for the building move, new foundation and extension. These tenders showed a saving of 55% against the cost of new construction and thus a contract was let, early in June 1958, with Hartshorne and Nicholas Associates, a firm of experts in this type of work.

The Forestry building is a 30 year old three storey brick and stone structure. Exterior and interior brick walls are bearing walls, while floors and roof are reinforced concrete beams and slab. The main concrete floor beams, which are at 14 ft. 6 in. centres, span 21 ft., in a north-south direction, between the 2 ft. thick external walls and the 1 ft. 6 in. thick brick bearing walls of the central corridor, running east-west. The central corridor, which extends the full height of the building, is 8 ft. wide.

The overall sizes of the building are:

Length (east-west)	84 ft.
Width (north-south)	57 ft.
Height (basement floor-roof)	55 ft.

The estimated dead weight of the structure above the "break point" for moving was 3,500 tons. (The "break point" occurred approximately 3 ft. below the finished first floor level).

Work was started on the building at the end of June 1958. Holes were cut through the walls of the structure to accommodate seventeen 14 in. x 16 in. x 142 lb./ft. wide flange needle beams which were inserted through the building in a north-south direction. Under these seventeen beams a further four beams were inserted in an east-west direction and thus a grid of steel beams was formed which supported the structure when being jacked and moved.

The top flanges of the upper steel needle beams provided support for 8 in. x 6 in. oak secondary needle beams which in turn supported walls, ends of existing concrete beams and other points in the structure. These oak needles also acted as cushions under points of bearing. The layout and wedging up of these oak needles required much skill and care for these members were the only ones in direct contact with the structure.

The difference in level between the existing first floor and the final first floor was 6 ft. (see Fig. 1). This "lift" was planned in three sections:

(1) The structure was jacked up 3 ft. 6 in. along the north side and 3 ft. along the south side. The whole structure was, therefore, on a 6 in. tilt from north to south.

(2) Inclined track beams laid under the support grid were given a rise of 1 to 120 in a northerly direction. About 2 ft. was gained on these inclined tracks over the 250 ft. move.

(3) When the building was over the new foundation it was levelled off and then jacked up the remaining 6 inches.

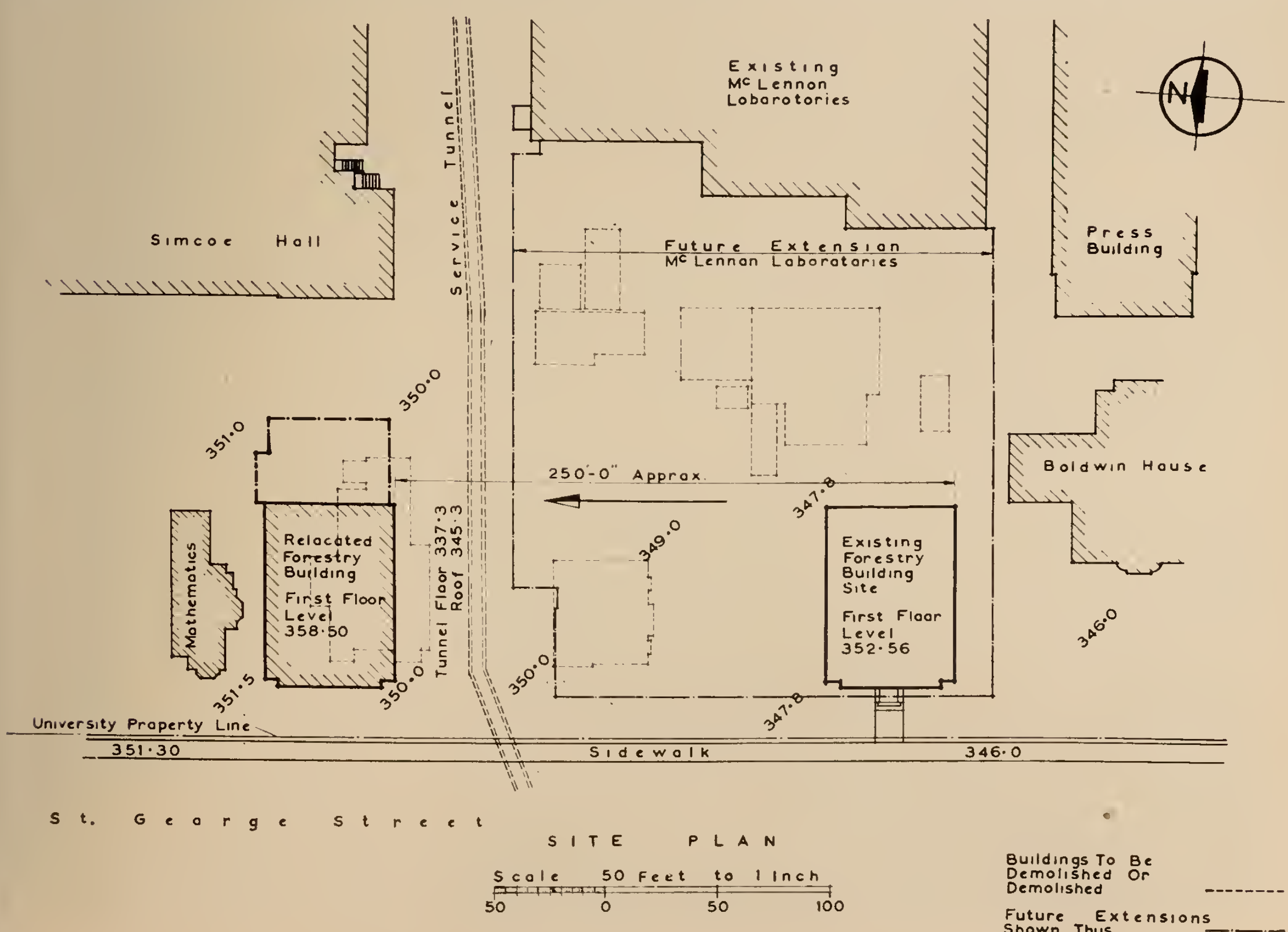
Forty-eight 100-ton Duff-Norton hydraulic jacks, with a rise of 6⅛ in., were used to jack up the structure. The jacks were arranged in four lines corresponding to the support beams running in the east-west direction. Each line of jacks was worked to definite sequence and no line of jacks was more than ⅛ in. ahead of the other. In this way the structure was jacked up as evenly as possible with all lines of jacks taking their share of the load.

It took about one day to re-set the jacks and build up cribbing after each 6⅛ in. rise. As the building was raised the efficiency of the jacking crew decreased since they were obliged to work from staging. (Fig. 2 shows the layout of jacks and cribbing when the building was raised about 18 in. and explains the reason for keeping the height of the initial lift to about 3 ft. 6 in.)

On completion of initial jacking the tilt of the building was about 1 to 120. The ground slopes up 24 in. from the old site to the new site (see Fig. 1) therefore the tilt of the building approximated to the slope of the ground and the track beams. A much more positive bearing was thereby obtained between the track beams and steel support frame and costly shaped packers were eliminated.

Before the building was moved and in order to provide additional bearing between the track beams and the steel needle beams a further four 14 in. x 16 in. x 142 lbs./ft. wide flange beams were inserted through the structure in an east-west direction. Eight sets of track beams were then run in north-south under the steel needle beams. A track beam comprised one 14 in. x 16 in. x 142 lb./ft. wide flange beam vertically on top of another with a 2½ in. diameter mild steel roller sandwiched between the flanges. The rollers were 2 ft. long and at 15 in. centres. All track beams were tightened up against the steel needle beams to ensure positive bearing and a 60 ft. length of track was continued, at the rise of 1 to 120, outside the structure and blocked with 8 ft. x 6 in. x 8 ft. oak baulks to distribute the loads from the tracks to the ground. The estimated ground pressure under the track beams was about 1¼ tons/sq. ft. which is a con-

Fig. 1. Plan of the area involved; showing existing Forestry building site, relocated forestry building and ground levels over the land traversed.



servative bearing pressure for the hard brown and grey clay strata under the move area.

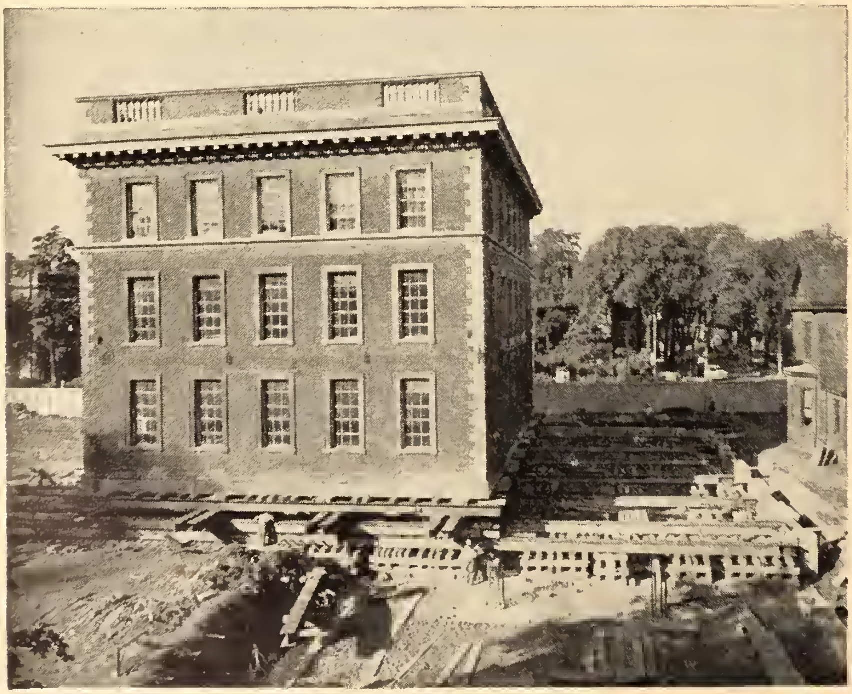
The maximum settlement observed on the track beam for a 60 ft. move was 1¼ in. while the relative settlement between individual tracks was no more than ½ in. The support beams of the structure appeared to adjust to these relative differences with no excessive strain imposed upon the structure.

Power for the move was obtained from two Mack Diesel trucks, each of 260 horsepower. Each truck had a 25 ton Silent Hoist winch mounted on the rear. Cables from the winches were arranged through a 6 line system of return blocks attached to various points of the steel support frame under the structure. The end cable of the six line system was anchored to a "dead man" in the ground. For the first 120 ft. of the move the trucks were positioned to pull the building towards them but for the last 130 ft. of the move they were arranged so as to move the building away from them. The two truck positions involved a simple rearrangement of cables from the winches, structure and anchor. (Fig. 3 shows the building just over the new foundation. Notice the steel beam at the end of the track beams being used as an anchor).

Preparation for each 60 ft. move took about one week, whereas the actual move took about 7 or 8 hours to complete. It was very important to maintain a balanced pull on each winch as the structure moved. Varying tensions on the cables tended to slide the structure off line and when this occurred the rollers would "fight" or bind each other. The structure was therefore moved in increments of 5 ft. and after each increment the rollers were trued up and re-centred. When the structure did move off line a correction was made by splaying the rollers in the direction of the required adjustment.

Fig. 2. The jacking crew at work: At this point, the building was being raised a further 18 in. and it was necessary for the men to work from staging.

Fig. 3. Here, the building has come to rest over its new foundation after moving 250 ft. from the old site.



The structure was relocated on the 23rd September and student classes in Forestry commenced on the 29th September. Underpinning was carried out while classes were in progress. The total time for the moving of the structure was 12 weeks while the new basement and extension was completed at the end of December 1958.

There was no structural damage to the building as a result of the move although a small sum of money was spent to tuck point parts of the exterior where the mortar joints to the brick and stone had spalled off.

This type of project is common in the United States particularly where highways are constructed through built-up areas. There appears to be no limit to the size or type of structure moved for the author has heard of 12 storey public buildings being relocated to preserve the structure and facilitate economic throughway construction. Some of these structures have been moved while the occupants still used all the facilities of the building and pursued their normal business day. The economy of moving a large structure varies with other circumstances but perhaps we may pause in the future to consider the possibilities of this technique.

A TYPEWRITTEN GRAMMATICAL WORD COUNTER

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Seattle, Washington., U.S.A.

This paper describes a simple electronic circuit counting exactly the number of grammatical words in a text as soon as they are typewritten. Such a device has already been constructed and has been described by the author.[1] Subsequently a public demonstration was given at the 1957 Annual Students Night of the E.I.C. Since that time the circuit has been completely redesigned and the previous limitations no longer exist.

As input or sensitive device, the first counter required complicated mechanical switches for sending pulses sequentially (as indicated on fig. 1) to the control unit. These were not commercially available and required tedious adjustments. Also this configuration resulted in poor accuracy at speeds higher than about 50 words per minute.

To obviate these shortcomings, the present counter uses only D.P.D.T. and S.P.S.T. switches which are fastened rigidly under the keyboard of the typewriter. This improvement has been possible after a new all-electronic circuit had replaced the previous one.

Definition

Since the computer proposed herein counts words, we must therefore define a word for our particular application. Any dictionary word (simple or compound), proper names, numbers, (regardless of the number of digits) can be detected and counted by the computer. Hence, a word is not a mere stroke average; the pronoun *I* for instance, must count just as heavily as the noun *antidisestablishmentarianism.* Moreover, the words are counted *grammatically;* the computer sees no difference between a simple word like *cat* and a compound noun like *brother-in-law.*

To sum up, let us say this special purpose computer has been programmed to solve the equation:

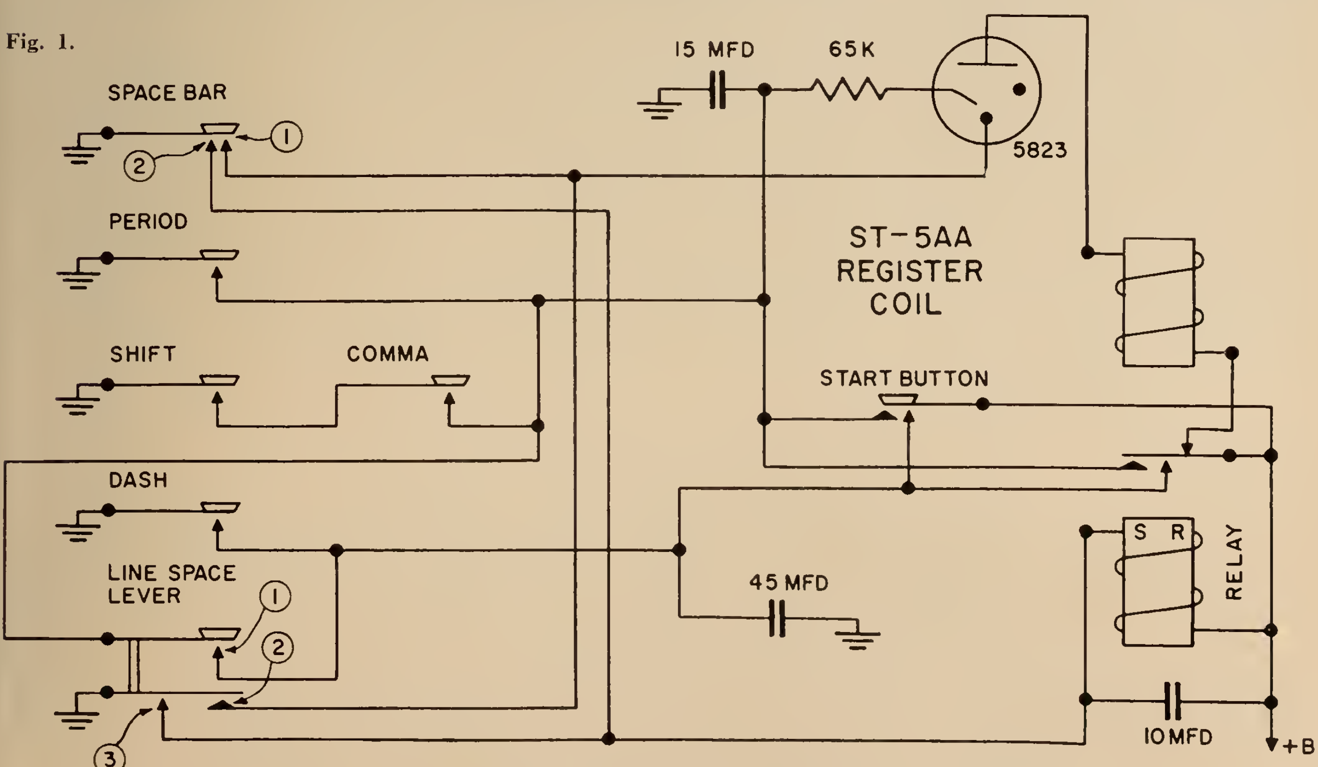
$$W = (S) + \frac{(S_s)}{2} + (L\text{-}L_h).$$

This equation infers that W, the number of words in a text, must be the number of times an electro-magnetic counter is energized by the computer circuit. Current (d-c pulse) flows through the register coil after either one of three predetermined conditions has occurred: (S) when the space bar is depressed between the words, ($S_s/2$) when the space bar has been depressed twice after a sentence, (L-L_h) when the line spacer lever has been actuated at the end of a line (L) which is not terminated by a hyphen (L_h).

A more detailed explanation for this setting will follow under the heading *Description.*

Since the switches are rigidly fastened to the keys, we have a built-in program. Therefore if one

Fig. 1.



GRAMMATICAL WORD COMPUTER

wishes to simulate another equation for "W", a mere relocation of the switches solves the problem.

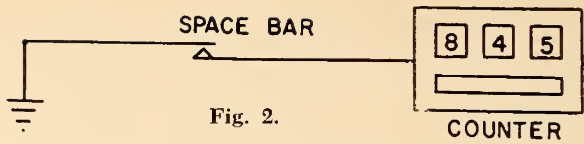


Fig. 2.

Description

The easiest solution to the problem of counting words printed by a typewriter seems to place a normally open S.P.S.T. switch under the space bar (fig. 2). Thus, every time a word is printed, the typist makes a space and contacts close the coil circuit of an electro-magnetic counter adding one to the total. However, it is a common office practice to leave two spaces at the end of a sentence and it follows therefore, that by using the single switch circuit, the last word of any sentence is counted twice. To remove this difficulty, we need four additional switches and a memory (fig. 3). The memory is a bistable circuit which stays on until it receives a pulse from the switches connected to the *gating bias,* then it turns off and must be re-set.

One of these switches performs two functions: it is operated by the period key and it also sends a pulse to the memory when an exclamation mark ends a sentence, since this punctuation mark necessitates the use of the apostrophe and the period keys sequentially. The other two switches are in series: one is actuated by the shift key and the other, by the comma key since both have to be depressed simultaneously to print an interrogation mark.

Therefore, according to fig. 3, the *memory and gate* circuit has no output after a period, an interrogation or an exclamation mark has been typed, and it stays off until the space bar is released after the first space. A switch then resets the memory (we shall see later how this is done). The second space after the sentence then triggers the counter and the last word is thus counted.

The circuit of fig. 3 requires further improvements. At the end of a line, the typist uses the line space lever and not the space bar. Therefore, when a word terminates a line, another switch (fig. 4) thereafter called *line space lever switch* closes the counter circuit and registers the word. Often only one or a few syllables of the last word can be printed before changing the line. Then the line space lever switch must *not* energize the counter.

Fortunately, in such a case, a hyphen tells the readers the word is not completed, hence a switch under the hyphen key can turn off a second memory (completely independent from the first one) and this prevents the line space lever switch from actuating the register. It also contains a re-set control as in the previous case. Finally, since both circuits now control the same register, they are linked together as shown in fig. 5.

This figure presents two rectangles marked memory and gate. These two functions take place in a one-tube circuit.

This circuit (fig. 6) performs the memory function from *partial-ionization* of the gas between plate and cathode of a glow discharge tube. In this manner the information is never lost unless intentionally erased.

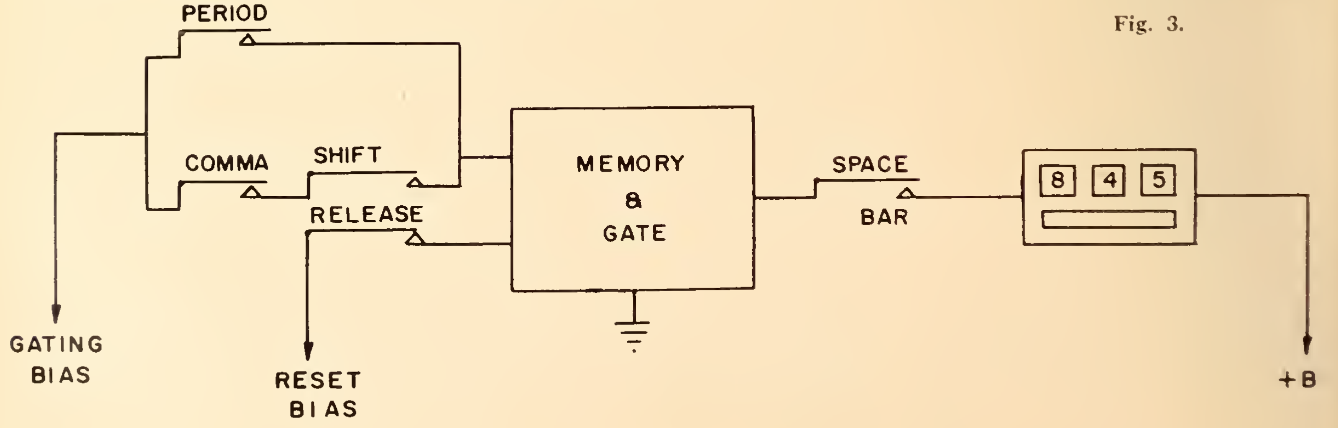
If switch S_1 momentarily applies a positive voltage on the starter, a small current flows through the tube and R_1. If S_3 is subsequently closed, a relatively large current (register coil d-c resistance being many times smaller than R_1) energizes the counter because the gas in the tube was already ionized. Only S_2 can interrupt the conduction of current in the tube; by-passing the current momentarily, the gas deionizes and the tube stops conducting as long as starter potential remains below break-down voltage. Although S_3 closes while the tube stays in this state the register cannot count. R_2 only prevents floating voltages to appear on the starter. (Note that a normally closed S.P.S.T. between R_2 and plate could have served the purpose of S_2 by cutting off the tube current momentarily).

In the actual computer (fig. 7), two of these circuits are connected in parallel to function as the two *memory and gate* of fig. 5. Switch S_2 now becomes, in circuit V_2, the *hyphen* switch. In circuit V_1 there are two ways for deionizing the triode: depressing the *period* switch alone or the *shift* and *comma* switches simultaneously.

The trigger switch S_3 of fig. 6, becomes in V_1, the S.P.S.T. contacts of the *space bar* while, in V_2, it becomes the S.P.S.T. *line space lever* switch. But the re-set switch S_1 is replaced by a more intricate means to send a positive pulse to the starter. As already explained, the triode deionizes after a punctuation mark, then the typist has to make two spaces. The computer uses the first one to restore ionization and the second one to energize the register; the S.P.S.T. contacts of the *space bar* switch, when depressed, charge capacitator C_1. When the space bar is released at the end of the *first space*, the capacitor thus brings the starter electrode to a high potential and ionizes the gas which then remains ionized because of R_1 (C_1 may discharge). When the space bar is depressed for the second consecutive time the S.P.S.T. contacts of the switch can now energize the counter since the tube is conducting.

The switch marked *release* is actuated, every time a symbol is printed, by a lever releasing a latching mechanism so that the carriage advances one stroke to the left. This is a dual-

Fig. 3.



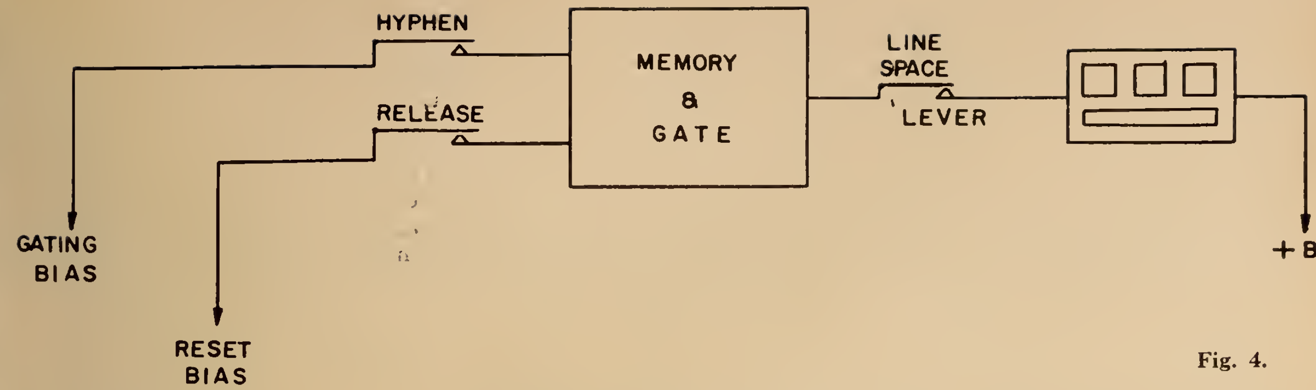


Fig. 4.

purpose re-set switch.

First when typing decimal figures, the period between the digits would have prevented the number to be counted as a word while depressing the space bar after this number because only the re-set would have been done then. Second, the hyphen between the parts of a compound word (or the dash replacing parentheses) deionizes the gas in triode V_2. But, since this hyphen has no relation with the end of the line, the *release* switch re-sets V_2 before the end is reached.

Conclusion

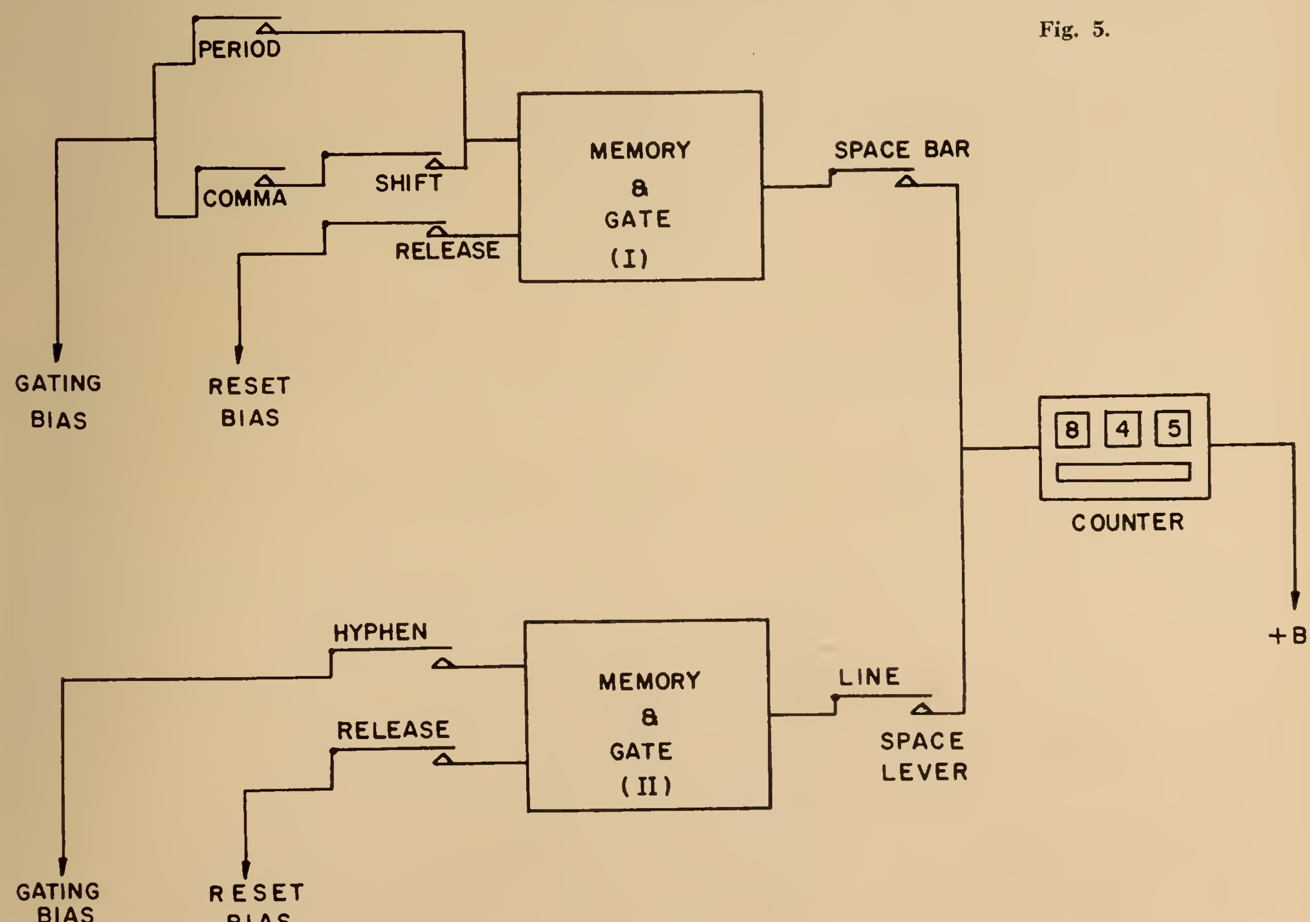
The reader who compares both circuits will easily discover the numerous advantages of the new computer over the previous one. Among the more obvious improvements he is likely to note the greater mechanical simplicity, the indefinite storage capacity and the faster time response. Hence, no speed limitations are encountered when a human person operates the typewriter (max. speed allowable by the counter 600 counts per minute).

Other improvements which might perhaps be overlooked are the following: a decimal number now counts as a word and a compound noun at the end of a line can be detected while, in the first computer, neither was counted. The re-set being done after the printing of any symbol (except the punctuation marks) cancels out the effect of punctuation marks when they are not followed immediately by a space or a change of line.

Typist mistakes such as erasures and strike-overs are relatively few and do not affect the counter as long as the space-bar stays at rest position. Therefore the typist should take care to use the tabulator key for paragraph indentation. Since there is no switch under this key, these spaces will not be registered as words. While existing rules are respected, no error should result.

The circuit should have a long trouble-free life because there are no filaments to burn out, no mechanical parts to wear out, nor critical circuits to adjust periodically. The only electro-mechanical component, the

Fig. 5.



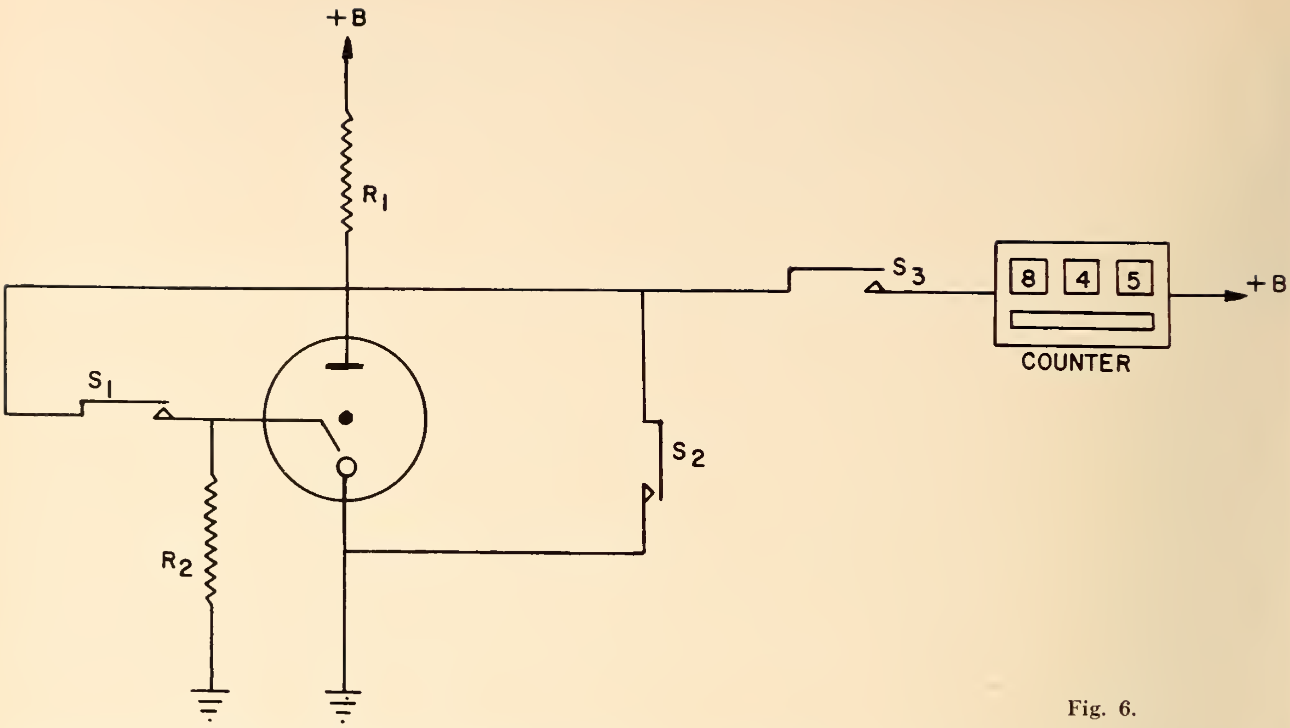


Fig. 6.

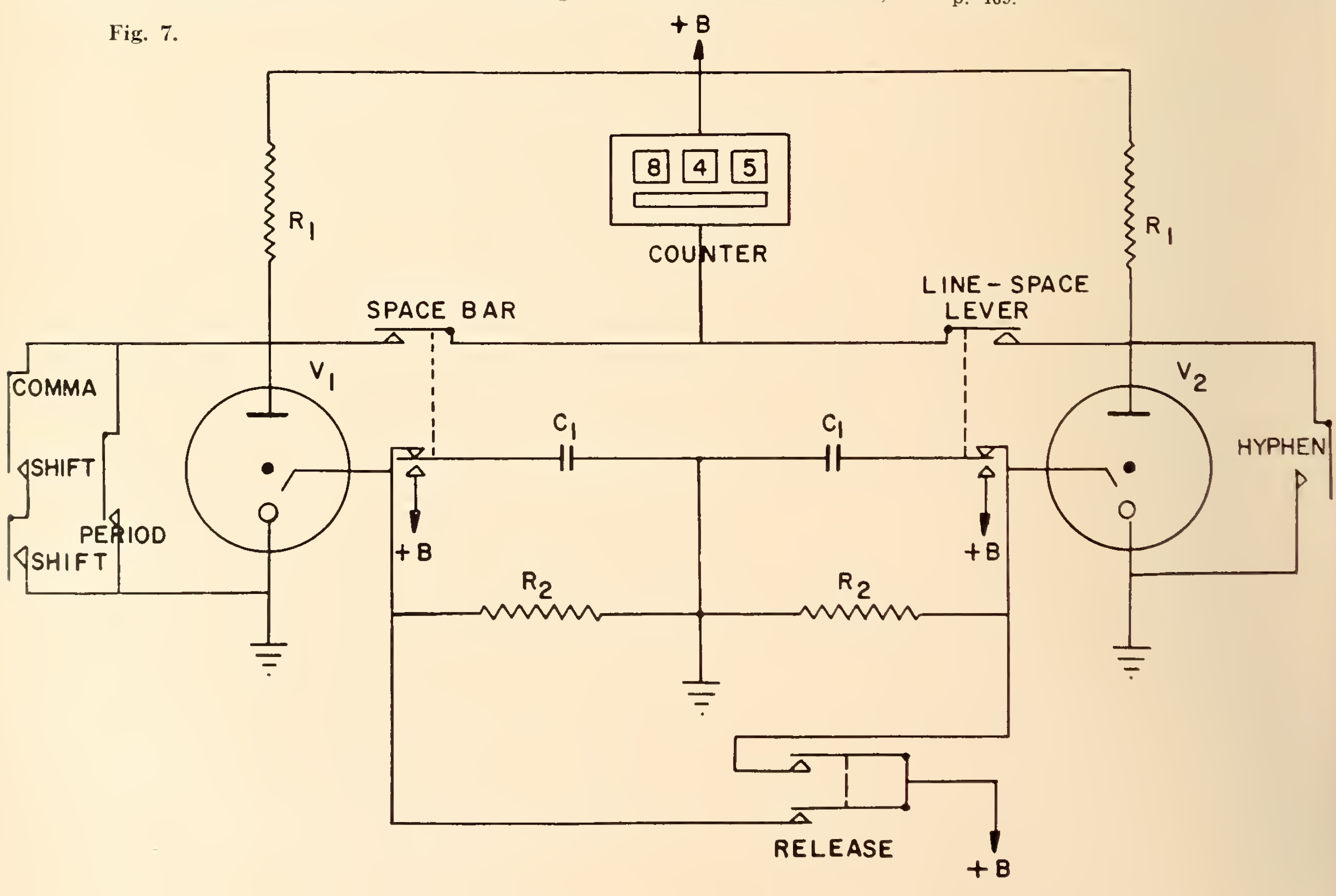
counter, shows no failure after more than three years of operation. The power supply is a standard semiconductor voltage-doubler which can be plugged in any 115 VAC outlet; no regulation is needed.

Potential users are governments and corporations employing many typists: the personnel office could evaluate at a glance the skill of a candidate or use the device for impartial promotion of actual employees. Newspapers and magazine publishers who pay articles on a per word basis would find it a very convenient and inexpensive way for counting words. The teletype and telegraph companies could also take advantage of this small counter. Last, but surely not least: the business colleges would thus be able to provide direct incentive for their typewriting students.

Acknowledgement is due Dr. J. François Perrier for assistance in preparing this article.

1. Scientific American, December 1956, p. 169.

Fig. 7.



CONSTRUCTION OF FOUNDATIONS

for

VERNON NARROWS BRIDGE

R. J. McTavish, Jr.E.I.C., *Field Engineer*
Dravo of Canada Limited, Toronto, Ont.

IN CONSTRUCTING a by-pass for Highway 11 around the town of Huntsville, the Ontario Department of Highways is eliminating the last bottleneck for traffic moving north from Toronto to North Bay. Travel through the District of Muskoka, one of Ontario's leading summer and winter resort areas, will thus be more pleasant. At the present time it is not uncommon for summer weekend traffic to be stalled for several miles on either side of the Huntsville swing bridge over the North Branch of the Muskoka River. The major structure of the by-pass, a four lane bridge over the Vernon Narrows, clears the water by 17 ft. and thus eliminates the need for a swing or lift bridge on the by-pass.

Vernon Narrows connects Vernon Lake to Hunter's Bay, forming the source of the North Branch of the Muskoka River. Although the bridge span at the Narrows is only about 700 ft., the nature of the river bottom presented difficult construction problems. The contractor had available portable floating construction equipment which proved to be most suitable for the project. The award for construction included the building of eight reinforced concrete piers and two abutments to support the nine structural steel spans and reinforced deck which will make up the completed bridge. Support for the piers is provided by pipe pile driven to rock through an average of 55 ft. of silt, clay and gravel.

Fig. 1. Set-up for testing pipe pile. Sheet pile cell was placed on top of cofferdam undergoing test and filled with 450 tons of sand and gravel. Jack inside the test cell transmitted load to piling.

Two phases of the assignment presented more than usual problems. These were construction of the below-water portion of the piers and load-testing of the pipe pile. Solution of these problems called first for careful examination of the plans, specifications and boring results.

Each pier base is made up of two tripod pipe pile supports with reinforced concrete caps, tied together by a reinforced concrete strut. Specifications required the 18-inch-diameter pipe pile to be driven with an open end to rock, cleaned out and a four-foot tremie plug placed in the bottom. The plug was to be driven out either three feet or to a refusal of 40 blows per inch at 15,000 foot pounds per blow. After this, the casing was to be dewatered and filled with concrete. The reinforced concrete for the caps and strut was to be placed "in the dry."

The specifications also required two of the pipe piles to be test loaded with 400 tons each for a period of 24 hours. Borings indicated that the depth below mean water level to bed rock varied from 57 ft. to 92 ft., with the water varying from 6 ft. to 13 ft. in depth. Overburden on the bed rock was indicated to be very soft for most of its depth.

Thus, the basic requirements for the pier base construction were:

1. A support frame or system of leads from which the pipe pile could be positioned and driven.
2. A dewatered area for placing the caps and struts.
3. A method of testing the pipe pile with 400-ton loads.

To fulfill these requirements, the contractor decided to use a circular steel sheet pile cofferdam for each tripod and cap, and a double-skin form for the connecting strut. Circular cofferdams require a minimum of interior cross bracing, and in this case provided an unobstructed work area. In addition, this type of coffer could be adapted to allow for a 400-ton test setup and would support a timber frame to hold and guide the pipe pile into position.

Construction procedure for each pier base was laid out as follows:

Set and drive the sheet pile for two 21-ft.-diameter cofferdams. Excavate within each coffer to a depth of ten feet below the bottom of the pier cap and fill this area with granular material.

Set pile driving frame on coffers and drive pipe pile to rock.

Clean out pipe pile, place and drive plugs, and place concrete fill in the pipes.

Place bracing rings in coffers and dewater.

Place circular pier cap forms and pour concrete.

Remove forms and pull sheet pile.

Place waterproof strut form, dewater and pour concrete.

Remove strut form and begin construction of the above-water portions of the pier.

Details of Pier Base Construction

FA-6 steel sheet pile in 30, 40 and 45-ft. lengths was used for the circular cofferdam construction. Enough sheet piling was delivered to the job site to permit the simultaneous construction of six cellular coffers. The sheet pile was set around a wooden template floating on four 45-gallon fuel drums. Four 4-ft. by 4-ft. by 3-ft. plain concrete blocks provided anchorage for the template.

Fig. 2. Driving pipe piles with a diesel pile hammer. Pipe pile positioning and driving frame was 16 ft. square by 16 ft. high and secured to top of sheet pile cofferdam by chains tightened with loggers' load binders.

Fig. 3. Ferrying concrete from shore to piers. Concrete was mixed on shore, transferred via shuttle car to four bottom dump concrete buckets on cable-operated ferry.

After setting, the piles were driven to grade by a Delmag D-5 diesel pile hammer. Since the original river bottom was generally below pile cap elevation and too soft to support any load, the material within the coffers was replaced with granular fill to a depth of 10 ft. below the pile caps. This insured against settlement of the pile cap forms and concrete.

The pipe pile positioning and driving frame, constructed of 12-in. square and 10-in. square timbers, was 16 ft. square by 16 ft. high and could be lifted easily onto the top of a cofferdam by either of two floating rigs at the site. Once in place, the frame was secured to the sheet pile by chains tightened with loggers' load binders. The cross beams for supporting the individual pipe pile during driving were similarly installed. 18-in.-diameter pipe pile, in lengths up to 85 ft., were slung above the centre point and lowered into position through the frame by a floating Lima crane with a 100-ft. boom. The piles were driven to rock by a Delmag D-12 diesel pile hammer operating in swinging leads.

After the pipe piles were driven, the driving frame was removed and the material inside the piles was cleaned out to rock by compressed air. The air was supplied from two connected 150-cubic-ft. air receivers fed by an Ingersoll-Rand 600 compressor. An 80-ft. long, 4-in.-diameter "blow pipe", connected to the air receivers through

100 feet of air hose and a 4-in., quick-opening gate valve was inserted into the material within the pipe pile. When the pressure in the receivers built up to 110 pounds per square in., the valve was opened and the resulting quick release of a large volume of compressed air forced the material up out of the pile. When pressure dropped to 35 pounds per square in., the valve was closed and the whole operation was repeated.

On an average, cleaning out an individual pile took less than an hour with this method. Clay, silt and sandy gravel were forced out easily, but a little more difficulty was encountered with the large chunks of stone just above bed rock, many as large as 1 ft. long and 4 in. in diameter. Special safety precautions had to be taken to protect men and equipment, for some of these stones were hurled as high as 80 ft. into the air.

Great care was taken to insure a clean bottom well founded in rock for these pipe piles. Tremie concrete plugs were then placed in the piles and driven to their required penetration by the D-12 hammer, acting through a mandrel from the top of the pipe pile. This mandrel was a 10-in. bearing pile with a 17-in.-diameter by 24-in. driving head at the bottom. The 10-in. pile was supported laterally from the pipe pile by means of 17-in-diameter plates welded to the flanges of the mandrel at 20-ft. intervals. With the plugs in place, the piles were dewatered by a No. 35 Ingersoll-Rand air pump, which was lowered into the pipe as the water receded. Finally, the piles were filled with concrete.

Next step was to place the cofferdam bracing rings and dewater the coffers. Each ring consisted of four layers of 2-in. wood, cut into 4-ft. segments and laminated to form a circular frame 4 in. smaller in diameter than the inside diameter of the coffers. The rings were wedged into place with timber wedges and the coffers were dewatered with a 6-in. pump. The pipe piles were then cut to grade and the granular material levelled at the proper elevation to receive the cap forms.

These circular wooden forms were constructed of horizontal wales of laminated 2-in. segments cut to proper radius, vertical 2-in. x 8-in. planking at 10-½ in. centres, and ¼-in. plywood lining. A hinge was built into one side of each form with a lock rod diametrically opposite at the strut location. Here the form was extended 12 in. in the shape of the strut to form a projection which would facilitate waterproof sealing of the strut form. To guard against settlement, the cap forms were supported both by the granular fill and by two beams spanning the top of the cofferdams. Two cap forms were fabricated for the job, so that each form was used eight times. After removal of the cap forms, the sheet pile was pulled by an air-

Fig. 4. "Blowing out" pipe pile after driving. An 80-foot-long "blow pipe" connected by hose to air receivers was inserted into the material inside the pipe pile. When pressure in the receivers built up to 110 pounds per square inch, gate valve was opened and sudden release of compressed air hurled rock and other material up to 80 ft. into the air. Cleaning pile to rock took about an hour.

Fig. 5. Form work on one of the eight reinforced concrete piers. Plastic cover was devised to provide protection from freezing temperatures.

operated pile extractor.

The double skin strut form was placed in halves, then pulled together and sealed by tightening the cables. Rubber strips built into the form sealed against the concrete projections of the pile caps. A tongue and groove arrangement of the two segments forced together made the bottom seal. Placing of the reinforcing steel and concrete followed dewatering of the form.

Construction Equipment Used

Two floating rigs were used on this contract — a standard type C-10 Whirler with a 65-ft. boom and a 20-ft. jib, and a 703SC Lima with a 100-ft. boom. Each crane was fastened to the deck of a 50-ft. square barge through two 36-in. WF beams. Each barge was constructed of 63 hollow steel cubes that had been shipped to the job in strings of nine and assembled at the site. These cubes measured 5 ft. x 7 ft. x 5 ft. A similarly constructed barge, which was 50 ft. long x 30 ft. wide, was used for material handling.

Pile driving was accomplished by two Delmag diesel pile hammers, a D-5 and a D-12, and a McKiernan Terry E-4 extractor pulled the sheet pile. The cofferdams were dewatered by a 6-in. C.M.C. diesel-driven pump and kept dry by several quarter-horse-power electric sump pumps. Two Ingersoll-Rand 600 C.F.M. rotary compressors provided the air needed for pile extraction, concrete plant operation, blowing pipe piles and, in the winter months, elimination of ice in the working area.

Concrete was mixed in a one-cubic-yard Smith mixer after the material was weighed in a 50-ton-an-hour Blaw Knox batcher. The mixed concrete was transferred via shuttle car to four Johnson-Dravo bottom dump concrete buckets on a cable-operated ferry, which operated between the shore and the various pier locations.

During the winter the work area was kept relatively free of ice by forcing compressed air through small holes in a 1-½ in. plastic hose laid on the bottom of the Narrows. The bubbles forced the warmer, denser water from the bottom to the surface where the combination of agitation and increased temperature prevented ice from forming.

Pipe Pile Tests

The specification calling for testing of two pipe piles with 400-ton loads represented twice the design load of 200 tons per pile. After 24 hours of

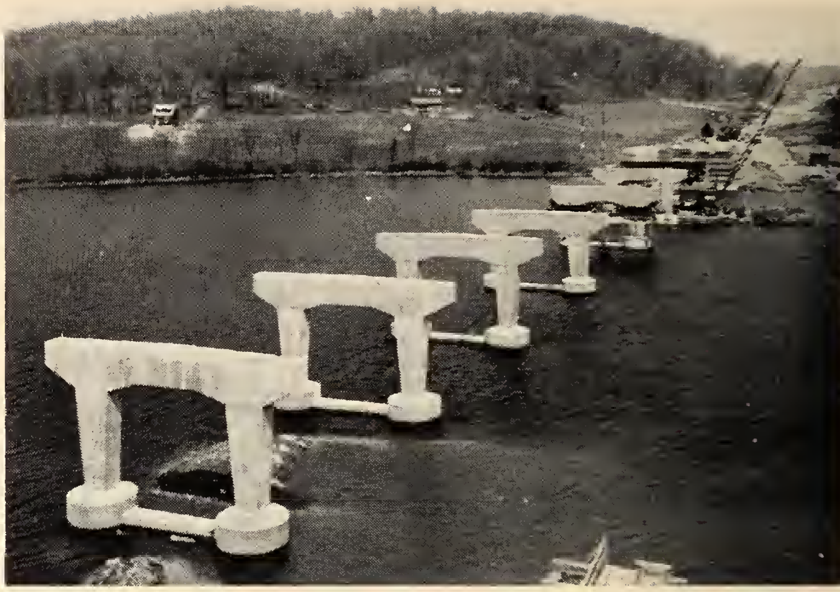


Fig. 6. Overall view of Vernon Narrows Bridge just before completion of piers.

load application, if the net deflection of a pile was less than ½ in., the pile was to be considered safe.

Before pile driving was started, the resident engineer indicated the pipe piles to be tested. Installation of the cofferdams and pipe piles was then carried out as previously outlined, except that longer sheet piles were used for the coffers.

After the pipe piles were filled with concrete, granular fill was placed to a level of 1 ft. above water, inside the cofferdam containing the test pile and to 9-½ ft. above water in the partner coffer. Two 33-inch WF beams tied together as a unit, and a 500-ton hydraulic jack were then set inside the test coffer. Next a 2-ft. thick concrete slab, reinforced top and bottom with No. 9 bars at 6-in. centres, was poured 8-½ ft. above the fill. It was held in place by clip angles welded to the sheet piling at the level of the bottom reinforcing mat. Bolts were embedded in the bottom of the slab to support the 33-in. beams.

An additional sheet pile cell was then placed on top of the cofferdam and held in position by bolted connections located at every sixth sheet. After removal of the falsework and support form for the 2-ft. slab, the beams and jack were set in position, and 450 tons of fill were loaded into the upper cell by clam-shell bucket. Before the test loading began, a 70-ton jack was placed between the test coffer and the partner coffer to resist the horizontal component of the 500-ton jack reaction. The 70-ton jack acted between the 2-ft. slab in the test coffer and a 1-ft. slab of plain concrete poured on top of the granular fill in the adjacent coffer.

As the 500-ton jack was operated, the test load was transmitted to the pile. This was done in 50-ton increments at one hour intervals until the full 400-ton load had been applied. An extensometer, calibrated in thousandths of inches was used to take settlement readings before and after each load increment. The maximum load was kept on the pile for 24 hours, with deflections recorded every hour. At the end of this time, the load was removed in 50-ton decrements over a 15-minute period, with rebound readings taken after each decrement.

Under the 400-ton load, the two piles settled an average of .70 of an inch. After 24 hours of full load, the figure was .75 of an inch. But when the load was removed, the reading was .15 of an inch. Thus the net settlement was only .15 of an inch, compared to the allowable settlement of .50 of an inch.

After completion of the test, the top cell and slab were dismantled and the beams, jack and granular fill removed, so that construction of the pile cap could be completed.

Erection of the Vernon Narrows Bridge was carried out under the supervision of the Ontario Department of Highways. Consultant for design of the bridge was T. O. Lazarides, Lount & Partner of Toronto. J. E. Boyer was superintendent for Dravo of Canada Limited.

THE DEVELOPMENT OF AN ELECTRONIC DETECTOR OF FLAWS IN PAPER

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Companies which manufacture and sell high quality paper, such as bond paper or book paper, must be very careful that defects such as small dirt spots or shiny marks in the paper do not reach the customer. At present the paper is checked by visual inspection one sheet at a time. A considerable number of measurements have been made to determine what characteristics of paper at a flaw are different from those of good paper, in order to determine which characteristic is most suitable to be used by an automatic detector to give a fairly reliable indication of the presence of the flaw. The method of detection should be suitable for checking paper travelling at several hundred feet per minute without marking or damaging the paper. On the basis of these tests an electronic flaw detector has been built.

The electronic flaw detector measures variations in the amount of light reflected from the paper, by means of photomultipliers. Lenses focus the light reflected from a small area of the paper up into the photomultipliers. Rotating mirrors in the path of the light beam swing the beam so that the spot being looked at travels across the paper. The size and shape of the spot is defined by an aperture in the optical system. Variations in the light reflected from the paper produce electrical pulses from the photomultipliers, which are used to actuate the sorting mechanism. Mercury vapour lamps illuminate the paper where it is scanned. The present model can check paper at up to 300 feet per minute, but could be modified to operate at a higher speed if necessary.

In a paper mill, great care is taken to make sure that the finished product is of as high quality as possible. In spite of all the precautions, defects do occur, such as dirt or holes in the paper. If the paper is to be used for such things as advertising folders, photographic sheets, or good quality books these defects cannot be tolerated, and must be removed. The present method of doing this is to sort every sheet of paper by hand. The process is slow and tedious, and consequently is expensive when one considers that the output of a company is measured in tons of paper. Furthermore, the girls who do the sorting can let factors such as fatigue or boredom influence their work.

An automatic flaw detector, which could pick out the defective paper with a fair degree of reliability, but faster and more economically than it can be done by hand, would be an advantage to the paper industry. The requirements of such a flaw detector are that it should be suitable for installing on an existing paper processing machine in a paper mill, and must operate at the speed at which the paper is going through the machine. On a typical fine-paper cutter this speed is of the order of 300 feet per minute. The flaw detector must be able to pick out the worst flaws reliably, and should be able to detect as many as possible of the less serious defects. It must operate more economically than the present system.

TYPES OF FLAWS

There are many different types of flaws which may be found in fine paper. Some of the defects may seem insignificant, but they spoil the appearance of good paper, particularly if there are many of them. Others may be rare, but should be watched for continually since they might cause trouble in printing operations. A few typical flaws are shown in Fig. 1.

Wrinkles

In spite of care in the manufacturing process, the finished paper may not be smooth, but may have obvious wrinkles, or just little 'waves' perhaps one-half inch apart.

Creases

One step in the treatment of paper in a mill is to put it through a calendar stack. Here the paper passes between smooth heavy rolls where it is subjected to a high pressure of several tons per square inch which gives it a smooth finish. If the paper runs into the calendar stack a little crooked, or if paper which has some wrinkles goes through, there is a good chance that some of it will fold over very slightly, and be pressed together. The result is that three layers of paper are passing through where one layer is barely able to go. The very high pressure breaks down the fibres of the paper and weakens the paper at this point. This is what is known in the trade as a crease. The paper may actually break and the crease then becomes a cut. The paper is much more liable to tear at this point, and may cause damage when it is going through a printing press.

Some creases are quite long, perhaps several feet. These usually extend along the direction of travel of the paper in the paper machine. Short creases, up to several inches long, may be at almost any angle, though usually not more than about 45° from the direction of paper travel. Since the paper has been folded slightly, it may be thicker at a crease than elsewhere, and a bump may be felt by sliding the hand across it.

Calendar Stamps

If a small piece of paper sticks to the calendar roll, it will leave its mark on the paper which is going through the roll, once every revolution. At the mark the paper is thinner and usually shinier than the rest of the paper. This defect is particularly annoying because it repeats at regular intervals along the web of the paper.

Dirt

In spite of great care in handling, it is possible for dirt to get on the paper. It may come on the paper after it has been made, or it may have been in the pulp. It is frequently in the form of small black or brown spots, which are quite noticeable on white paper. Even very small spots are bothersome if they come in groups, several spots on one sheet. Dirt is usually more opaque than good paper, and sometimes is thicker than the paper.

Colour Streaks

These defects apply to coloured paper, and occur if the dye has not mixed properly. The light reflection and light transmission characteristics of these are different from those of good paper, and are usually similar to those of dirt.

Holes

There may be holes in the paper perhaps an inch across, called slime holes, where the pulp was just a mixture of slime without the fibres necessary for strength. There may also be small holes, caused for example when a small piece of foreign material has come loose and fallen out of the paper. If, as is usual, the background is not the same colour as the paper, holes look like dirt.

Torn Edge

If the end of a roll of paper has been damaged, a piece at the edge may tear off when the roll is unwound.

Pasters

If the web of paper breaks or has been cut for some reason during the continuous processing then it is necessary to splice it, and this is done with a strip of sticky red paper. The web of paper is kept continuous, but the splice should be taken out before the paper goes to the customer. From the point of view of sorting paper, splices, or "pasters" as they are called, could be considered to be flaws. They are made red intentionally so that they are easily visible on white paper.

Table I

Defects	*Translucence*	*Reflectivity*	*Thickness*	*Strength*	*Smoothness*
Wrinkles.					x
Creases and Cuts	x		x	x	x
Calendar Stamps		x	x		x
Dirt.	x	x			
Colour Streaks . . .	x	x			
Holes.	x	x	x		x
Torn Edges.	x	x	x		x
Pasters.	x	x	x		x

A brief resumé of the above information is given in Table I. Some characteristics which may differentiate these flaws from good paper are indicated.

STATIC MEASUREMENT OF FLAWS

Table I shows some of the characteristics of flaws which may make detectable differences between them and good paper. The problem is to make a working model of a paper sorter which will operate while the paper is travelling at the normal speed, several hundred feet per minute, and will use some characteristic difference to detect the flaws. Initial tests, to determine what measurement on the paper will give the most reliable indication of the presence of serious flaws, are more easily done statically, using fairly small sheets of paper with typical flaws, so this procedure was followed.

An important consideration is that the method of measurement must not damage the paper. For example, some methods of measurement which were quite effective for detection of small cuts were not suitable to use because the paper was marked. Other factors to bear in mind are that the measurement must be done at a paper speed of several hundred feet per minute, on a machine with considerable vibration and without interfering with the normal operation of the machine. A device to make one type of measurement which would detect as many defects as possible would be much more useful than a device which would detect only one. The results of measurements of flaw characteristics noted in Table I, and also electrical characteristics, are outlined below.

Translucence Measurements

A light was placed above the paper, and a phototube was placed below, with an aperture between so that the light shone through only a small area of the paper. By sliding the paper around over the aperture and measuring the phototube current, the normal variations of paper density (or translucence) were measured. The defect was then placed over the aperture and the density compared with the normal paper density. The light transmission through good paper is not at all uniform, and in the paper tested the variation for each specimen was between 8 and 23 per cent of the average. The signals obtained from flaws were of the same order of magnitude, so it was difficult to distinguish between variations due to flaws and those which are normal in good paper.

Light filters were inserted between the light and the paper to see if there was any improvement. Some flaws could be detected slightly better, but others could not be detected quite as well, so the extra complication did not seem justified.

Reflectivity Measurements

Intuitively, one would expect that this would be the most reliable method of detecting flaws, since in most cases it is the visibility of a flaw which is objectionable.

The most sensitive setup is that which gives specular reflection, i.e. the paper acts as a mirror and reflects the light beam directly into the phototubes. A number of sheets of paper with five different types of flaws were checked. The results are shown in Table II, for two different positions of the light. In the first arrangement the light beam and the pickup beam were both at 45° from the normal, and in the same plane, so that the reflection was specular. The results are given in the second column of Table II. Then the light was moved to directly above, so the reflection was diffuse. The results are given in the third column of Table II. The figures given are the amount that the reflection at the defect differs from that of good paper, as a percentage of the value for good paper. The normal variations over good paper were two to four per cent of the average value.

Table II

Defects	Optical Setup	
	Paper	*Paper*
Wrinkles	13%	5%
Creases	24%	2%
Calendar Stamps	23%	11%
Dirt	45%	33%
Oil	35%	35%

It can be seen from the table that for most defects the system is more sensitive when the reflection is specular. It is easy to have specular reflection in a static setup, but more difficult if there is motion in the optical system. If a beam of light is swept along the surface of the paper it is important that the reflection should be either specular or diffuse, but not changeable. If the beam passes through a position of specular reflection, the sensitivity to defects rises, and also, in general, the total quantity of light reflected.[1] The resultant surge from the photo-electric pickup is very undesirable.

The angle at which the light strikes the paper has some influence on flaw detection. If the light shines directly down on the paper, the brightness per unit area is greatest for a given source power, and the phototube current is highest, which is an advantage, as will be explained later. If the light strikes the paper from a source near the paper level i.e. if it grazes the paper, it will throw shadows, and this is particularly advantageous for detecting creases and wrinkles. This is partly responsible for the large signal from wrinkles and creases, as shown in Table II, when using a light beam at an angle rather than straight down.

The size of the area on the paper which is being examined has an important effect on the sensitivity. If the human eye is looking at a large area, the brain can focus attention on a small spot, but a phototube looks at all its field of view uniformly. If it is necessary to focus attention on some small spot, the field of view must be restricted. The signal from a small flaw could be expressed as $E = R.S.$ where

- E is the signal from the defect, and is the difference between the output at the defect and the output away from the defect;
- R is the ratio of light reflected per unit area from a defect and from good paper;
- S is the ratio of the size of the defect (within the boundary of the photosensitive area seen by the phototube) and the size of the photosensitive area.

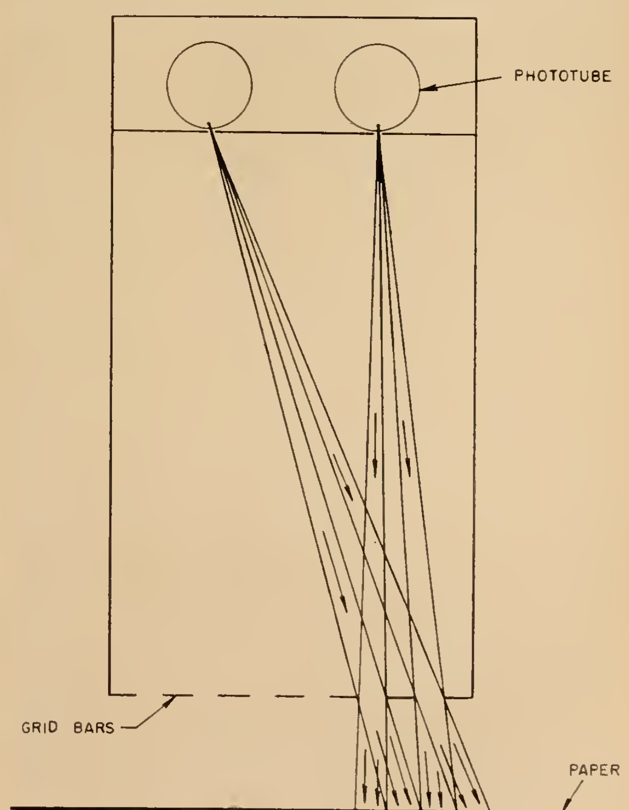
R is a constant for any given flaw, hence, for a maximum E, S should be as large as possible. For large defects $S = 1$ and for small defects S should be kept as close to 1 as possible. However, as will be seen later, in order to examine the whole of a sheet of paper, a large photosensitive area is advantageous. A reasonable compromise spot size is 1/64 square inch.

The value of R for any defect is rarely greater than one, that is, few defects reflect more light per unit area than does good paper. This applies particularly to coated paper which is usually fairly shiny. Hence a detector which could measure only reductions in the average reflected light would be satisfactory.

A test was made to compare transmitted light and reflected light for the detection of typical flaws in several sheets of paper. The signals in both cases were about the same, averaging about 12% beyond the normal level. However, the average variation in light reflected from good paper was 1.5% of the average level, while the average variation in light

Fig. 1. Typical Paper Flaws

Fig. 2. Petascope System



transmitted through good paper was 11%, the same order of magnitude as the signals. Therefore light reflected from the paper is much better than light transmitted through the paper for detecting small flaws.

The measurement of the light reflected from paper is the best method which has been found for detecting dirt or other defects where the value of R is significantly different from one. These include colour streaks and pasters, and also holes and torn edges if the background is different from paper, which is easy to ensure. Calendar stamps can be detected fairly well by this method. Stamps on uncoated paper are one of the defects where R is often greater than one. Unfortunately, small wrinkles and creases cannot be detected by reflected light, and other methods were tried to record these particular defects.

Table III

Type of Defect	Measured Characteristics					
	Translucence	Reflectivity	Thickness	Strength	Smoothness	Electrical Qualities
Wrinkles	No	Very Poor	No	No	Fair	No
Creases and Cuts	Very Poor	Poor	Poor	Poor	Fair	No
Calendar Stamps	No	Good	Very Poor	No	Very Poor	No
Dirt	Poor	Good	Poor	No	No	No
Colour Streaks	Poor	Good	No	No	No	No
Holes	Good	Good	Good	No	Fair	Good
Torn Edges	Good	Good	Good	No	Fair	Good
Pasters	Good	Good	Good	No	Good	No

Thickness Measurements

At a crease or cut, the paper is folded over and rolled together between the calendar rolls, so there may actually be three layers of paper at this point. If the creases are large, the thickness is greater than that of good paper, and they could probably be detected by a thickness gauge, but they can also be detected by other methods, e.g. by reflected light, just as easily. If the creases are small, there is usually some increase in thickness, but it may not be large. For example, paper which was 0.0045 inch thick was 0.0053 inch thick at a small crease. The thickness of the paper frequently is greater where some dirt has become embedded in the paper. For example, an easily visible piece of dirt may increase the paper thickness from .00325 in. to .00375 in. or even .0040 in. It is possible to build a thickness gauge which will detect this difference on a web of paper perhaps 60 in. wide running at 300 ft. per minute. However it is not easy and the precautions which are necessary to prevent the vibrations of the machine from actuating the detector are considerable. In addition, the machine operator must be able to thread the leading edge of the paper through the machine. Also some serious defects do not produce any significant change in paper thickness.

Measurement of Paper Strength

It seemed reasonable to try to use the characteristic weakness of the creases to locate them.

Applying tension from the edges across the paper is effective if the creases are near the edge, which they frequently are. It also tends to detect the long creases which run along the length of the paper, as they are stressed in their weakest direction. If there is enough tension to break most of the creases, even good paper is stretched slightly and this is not permitted.

A standard machine in a paper mill quality-control laboratory is a Mullin Tester. The paper under test is clamped in a ring with an inner diameter of about 1-1/8 in. and pressure is slowly applied to the circle of paper in the centre. The pressure at which the paper breaks is a measure of its strength. This could be used to detect a crease. For example, using one type of paper, the good paper broke at readings of 19 to 24-1/2, while at a small crease, it broke at 8 to 13-1/2. Hence, this is a good indicator, but unfortunately the paper is damaged at a reading of 12 or even less. Applying pressure by a rubber diaphragm and oil pressure, or by direct positive or negative air pressures or by a 1/2 in. ball on the paper, gave substantially the same results, but all these methods had to be rejected because they marked the paper.

Measurement of Smoothness by a Crystal Pickup

An ordinary record player crystal pickup was used with a 2-3/4 in. darning needle as the stylus. The crystal was placed on its side with the side of the needle near the point resting on the paper. As the paper slid past, a slight bump could be felt at a crease or cut, and this produced a very good signal from the crystal. On a test setup, using a piece of paper on a drum about 10 in. in diameter, this worked very well, and would pick out small creases and yet not mark the paper. However, anyone who tries to make a Hi-Fi set out of a paper machine will find that he is in trouble. The "rumble" and "wow" of the full size "turntable" is beyond hope and this promising method had to be given up. There are three other disadvantages: the output is partially dependent on paper speed which may be anything from zero to full speed; the crystals could not be placed closer than about 3/4 in. apart, and a crease along the length of the paper could possibly slide between two needles unnoticed; and it is difficult for the machine operator to thread the leading edge of the paper through without damaging the crystals.

Measurement of Smoothness by Vacuum Leakage

If paper is set on a smooth surface which contains a small hole which is connected to a vacuum system, the paper will block the hole, except for the air which may leak through between the paper and the surface. If the paper is very smooth, the leakage between the paper and the table should be small; but if the paper has a small ridge on it, such as might be found at a crease, one would expect the leakage to be larger, and this possible method of detection was examined. On smooth paper there is some correlation when measured statically. For example, on good paper the readings (in arbitrary units) were from 22 to 28, and the readings at a crease were from 28-1/2 to 34. However using the paper which did not have a smooth finish, the leakage at all times was fairly high, and the change in leakage due to a crease was only a small and unreliable amount more.

Measurement of Smoothness With Oblique Light

As mentioned previously the bump at a crease throws a shadow if it is illuminated from one side by a light barely above the surface of the paper. This is one of the better ways of detecting creases, but there are certain disadvantages. Since the light strikes the paper at a small angle, the illumination per unit area on the paper is low, even when using a bright light, and the sensitivity for other defects is low. Consequently, if light is to be used for detecting creases, it is not very satisfactory for detecting other types of flaws. Such a method is also sensitive to strain wrinkles which may appear when the paper is running over a roll. In spite of these defects, this method seems more satisfactory than any other that has been tried.

Measurement of Electrical Characteristics

If paper is tested by placing it between two electrodes, it is found that the conductivity and the dielectric strength of most flaws, except holes, are substantially the same as of good paper. Pieces of dirt sometimes have higher or lower values, but not sufficiently dependably to use this measurement as a method of detecting them.

A patent was issued in 1943 for a device which claims to detect flaws by a measurement of the dielectric constant.[2] However it is very difficult to get a consistent indication of dirt or any other flaws except holes by such a measurement. The main difficulty is that the measurement is of the structure of the paper which even for good paper is not at all uniform, and the variations of the dielectric constant over good paper are frequently greater than at a flaw.

SYSTEMS FOR DETECTING FLAWS IN MOVING PAPER

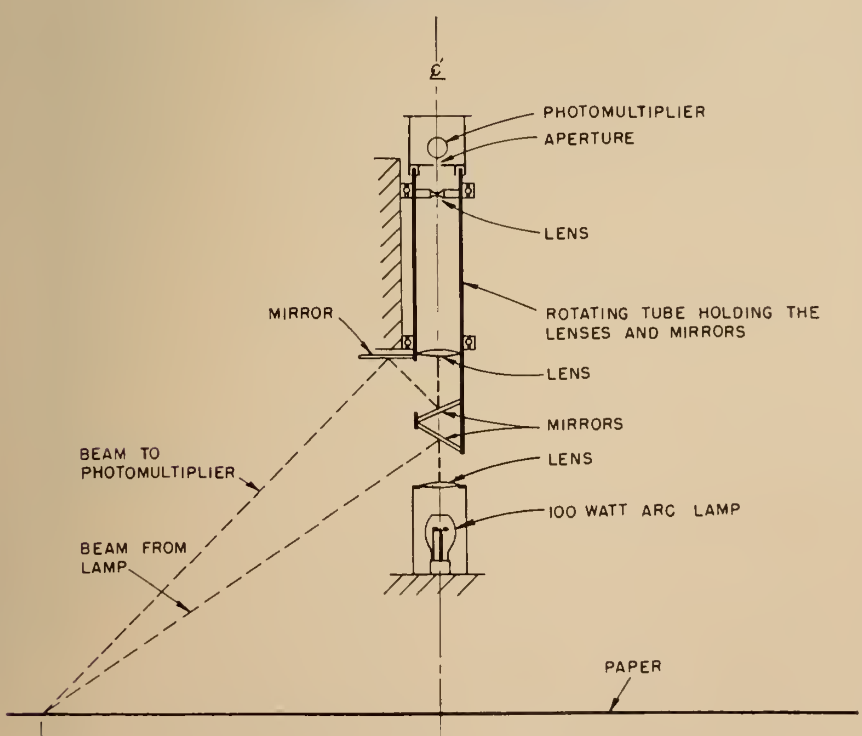
Before building a working model of a paper flaw detector, it must be decided which one of the above methods of measurement should be used. We now have more information than was given in Table I, and this is shown in Table III, which gives the relative merits of different measurements for detecting different flaws.

Reflected light appears to be the best for detecting the largest variety of flaws. Measurements of paper smoothness are best for detecting creases and cuts and wrinkles, but can detect little else. Since at least the larger creases can be detected by reflected light, this should be used. An arrangement which gives specular reflection has the highest sensitivity, but because of the difficulty of maintaining this during motion, it is better to avoid it and use diffuse reflection. The photo-electric pickup may look at a large area or a small area of the paper. Both methods have been tried and will be described.

Petascope System

In 1936 a photoelectric system was described for detecting flaws in paper in which the phototubes look at a large area of the paper.[3] Something basically the same was built. A sketch of this is shown in Fig. 2. The paper was uniformly illuminated over an area of inspection about 4 in. x 4 in. About an inch above the paper was a grid of opaque bars, 1/4 in. across and 1/4 in. apart. About 6 in. above this were two phototubes, placed so that each could look at only half of the lighted area, that which was not hidden by the bars, and the field of view of one phototube was exactly that masked off from the other. The bars were placed perpendicular to the direction of travel of the paper. Each time the paper moved forward 1/4 in. the defect would move from the field of view of one phototube to that of the other. If the light reflected from the spot was less than that reflected from good paper, then the output of each phototube went down slightly as the spot came into its field of view. The difference between the outputs of the two phototubes was a wave whose fundamental frequency was an easily calculated function of the paper speed, and a narrow pass band filter could filter out the desired signals, assuming that the paper speed was constant and known. The main disadvantage is that the flaw which should be detected is small compared with the area that is being viewed. For example, if a flaw is about 1/16 in. across, the area of the flaw is about 1/256 square inch, and the area being viewed by the phototube is about 1/2 x 4 x 4 = 8 square inches. The ratio of areas is over 2000:1, so that even if the viewed area was reduced by a factor of 10 the ratio of areas would still be 200:1. The result of this is that a large area with an insignificant change of reflection would give as great a signal as a small mark with a serious change of reflection. The unwanted signals have the same frequency as the wanted signals so that they cannot easily be filtered out. The system was most sensitive to spots which exactly filled the space between the bars, and was less sensitive to any other size or shape of spot. Another system showed considerably more promise, so the investigation of this system was dropped.

Fig. 3. Equipment for Circular Scanning



Scanning

The best results on the static tests for small defects in the paper were obtained using a phototube, which was focused on a small spot on the paper not much larger than the smallest defect, and which measured the light reflected from the paper. Since a random check is not good enough, i.e. it is necessary to examine all the paper, a multitude of photosensitive spots covering the whole width of the paper, or else some method of moving the photosensitive spot across the paper, must be used. If a multitude of areas are examined simultaneously the bandwidth of the associated electronic equipment is small, but a multitude of phototubes and amplifiers are required. If one spot is moved across the paper, one set of amplifiers is enough, but the bandwidth must be greater, the signal-to-noise factor will be decreased, and the problem will involve signal discrimination from the noise. This last method seemed preferable and is the method used in the final model.

Once it has been decided that the paper will all be covered by scanning with one small photosensitive spot, there are several variables which must be fixed, but which are mutually dependent, and dependent also on the maximum paper speed and width. These variables are: number of scanning units, size and shape of the scanning spot, duty ratio of the photoelectric units, and scanning speed. The compromise between these factors which can be arrived at determines the particular optical and electrical setup used. If it is assumed that the maximum probable paper speed is 300 ft./min., or 5 ft./sec., this gives some indication of the required scanning speed.

Television Camera

One type of scanning which should be considered is electronic scanning, such as is used in a television camera. In an Image Orthicon, a light image falls on the photocathode and an equivalent image of electrical charges builds up on the target which is just behind it. The information at any point on the target is sampled by the electron beam once each frame, i.e., once each 1/30 sec., and the charge on the target is neutralized during the time between scans. This is quite acceptable for T.V. since there usually is very little motion across the screen in 1/30 sec. However, at 300 ft. per min. a flaw 1/16 inch across moves 32 times its own width in 1/30 sec. The flaw shows up as a blurred streak instead of a spot, and the contrast at any point is far short of what it would have been statically. This means that the signal-to-noise ratio for the camera is about the same as for a photomultiplier, and since they cost considerably less, photomultipliers and mechanical scanning are preferable.

Circular Scanner

The circular scanner was constructed as shown in Fig. 3. The light from an arc lamp was focused by a lens and mirror on a spot on the paper. The same spot was focused by two mirrors and lenses, through an aperture, to a phototube. The tube which held the mirrors and lenses was mounted in bearings and rotated by an electric motor around an axis which was perpendicular to the paper, below. The spot of light described a circle on the paper and in the experimental setup the circle was about 3 feet in diameter. There was a fixed distance from the lenses to the object on the paper, so the optical system could always be exactly in focus. A 100-watt arc lamp produced a bright spot on the paper of sufficiently high intensity. There were no complications due to shifting angles since the angles between the paper, the light beam and the pickup beams were all constant. The system proved to be quite good for the detection of small spots and other flaws in a test setup.

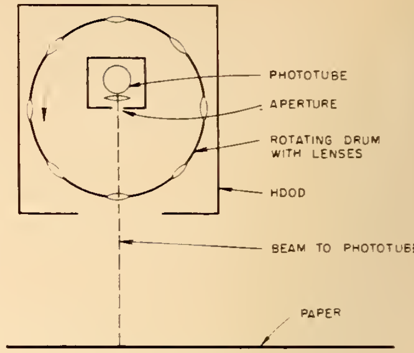


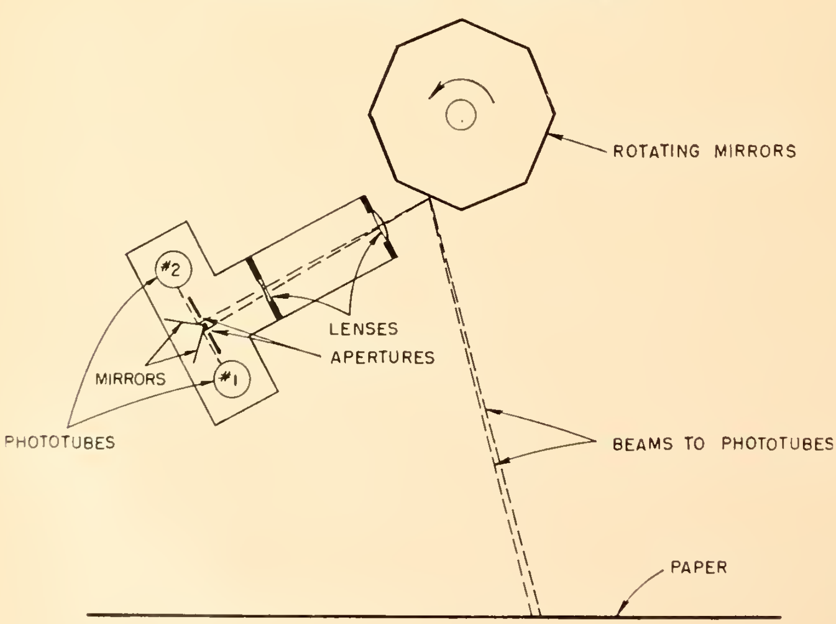
Fig. 4. Scanning System — Rotating Lenses

However, there were two serious defects. The photosensitive spot was about 1/4 in. long, and the rotational speed was about 1800 r.p.m., so the maximum paper speed was 1800 x 1/4 x 1/12 = 37-1/2 ft./min., which is about 1/8 of the required speed. Another and more serious defect is the fact that the total area scanned must be flat at all times, without strain wrinkles or flap. Anyone who has watched paper running between rolls in a paper mill, will realize that this is very difficult to obtain. For these reasons the circular scan method was dropped in favour of a line scan.

Linear Scanner

A machine which scans the paper along a straight line has the great advantage that the paper can be scanned where it is pulled tight over a machine roll. This should interfere very little with the normal operation of the paper processing machine. It is difficult to get a uniform illumination on the paper across its full width, but in spite of this, the linear scanner is the best of the methods tried. The model of the paper scanner which has been built uses a linear scan, and a description of this is given below.

Fig. 5. Scanning System — Rotating Mirrors



DESCRIPTION OF THE DETECTOR

Scanning System

Two possible methods of moving the scanning spot across the paper, i.e. swinging the beam of light from the scanning spot on the paper to the phototube, seemed feasible. One method is to rotate the whole optical beam.[4] A number of lenses can be mounted on the periphery of a light tight drum, which is driven by a motor. A phototube can be mounted inside the drum, but not attached to it, as shown in Fig. 4. As the drum rotates, each lens in turn sweeps the beam across the paper. This appears to be satisfactory if there is one phototube, but there are certain advantages

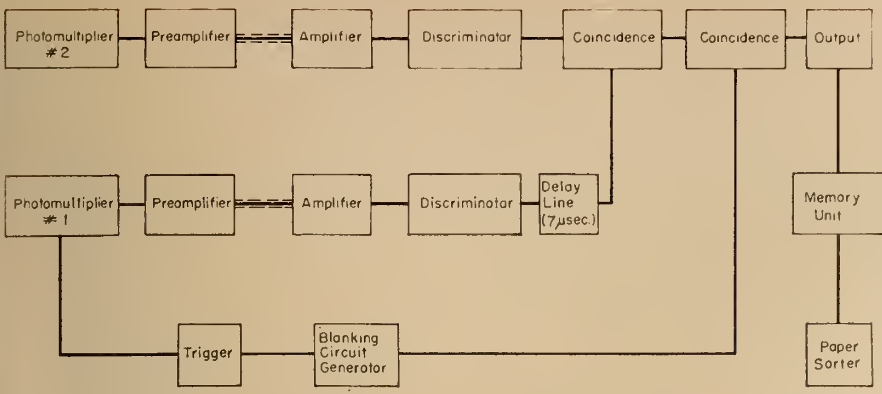


Fig. 6. Paper Flaw Detector — Block Diagram of Circuits

to be gained from using two phototubes, as will be explained later. In this case it is better to bend the light beam with mirrors. A number of mirrors on the periphery of a drum are placed in the beam path as shown in Fig. 5. As the drum rotates the mirrors swing the light beam across the paper. The drum has 8 mirrors rotating at 1800 r.p.m., to give 240 scans per second.

Illumination

The paper must be uniformly illuminated at the scanning spot all the time. There should be no variations due to changes of the spot position, or due to fluctuations of the light intensity. One method is to follow the scanning spot with a light spot from a d.c. arc light. In order to avoid variations due to changes in light beam angle at the paper when using a linear scan, it is easier to use fixed lights and illuminate the whole path along the paper. Using a row of reflector spot lights, it is not possible to get the output uniform enough, and the output shows a bump at every light. Fluorescent lights are efficient, but too low in intensity.

Two 3000-watt mercury vapour lamps are the most suitable. In order to get a light which does not vary with time, the lamps should be run from a d.c. supply, but they will not operate this way. They are run from a two-phase 60 cycle supply. This gives 240 peaks of light per second, one for every scan. In this way, with the same number of scans as light peaks, there is very little 120 cycle ripple in the output of the phototubes.

The 3000-watt lamps are suitable for getting a light which is uniform across the paper. The arc is 48 inches long. Plane mirrors perpendicular to the ends of the lights produce the effect of having a light source of infinite length, so the light on the paper is very uniform for about 52 inches. This is the maximum width that can be handled by one scanner. The lamps are placed about 18 inches above the paper, and elliptical trough reflectors reflect the light down to a line on the paper. Considerable heat as well as light is reflected down, and a mechanical baffle must be used to keep the heat off the paper when it is stopped. A disadvantage of the lights is that the light output is a function of both line voltage and lamp temperature, and electronic compensation must be made for any variations due to these factors.

Optical System

The optical system is shown in Fig. 5. Two lenses focus an area of the paper through an aperture to the photomultiplier. The aperture, which is directly in front of the photomultiplier, defines the size and shape of the scanning spot on the paper. In the discussion of a suitable size of the scanning spot, 1/64 sq. inch was said to be reasonable, and a spot 1/4 in. x 1/16 in. has been used. The narrow dimension should be about the same as the diameter of the smallest defect likely to be met, about 1/16 in. The long dimension of the spot, 1/4 in., depends on the maximum paper speed and the scanning speed. With 240 scans per second and a maximum paper speed of 300 feet per minute, each scan must cover 1/4 in., which is the required length of the scanning spot.

In order to discriminate between the signals and noise, an electrical coincidence is used, which requires two signals, exactly in phase, from two photomultipliers. If one optical beam is divided by a mirror which reflects 50% of the light into one photomultiplier and transmits 50% of the light into the other, the signals from both photomultipliers are exactly in phase, but each tube gets only 50% of the available light. If two separate beams are used, one must be slightly ahead of the other and an electrical delay must be used to bring the leading signals back into phase. However, each photomultiplier gets all the available light. This system seems preferable, and is being used.

Photomultipliers

Photomultipliers are used to convert energy from the light beam into electrical signals. Photo-transistors and solar cells are not suitable because they are sensitive to red and infra-red light, and they can not see many common defects which are not the right colour. Selenium cells respond too slowly to be useful.

As has been mentioned, one of the problems is to detect signals in noise. Most of the noise is produced in the photomultipliers, and it is important to keep this as low as possible. The conditions for low noise are a photocathode current as large as can be managed without saturating the output stages. To get the maximum photocathode current, tubes with high photocathode sensitivity are picked. Also the light intensity at the photocathode is made as high as possible. In order to get a reasonable depth of field in the optical system the aperture must be as small as possible, and this is another reason for high light intensity. The light requirements also are responsible for choosing two beams of light to the phototubes, and an electrical delay on one line, rather than splitting one beam between both tubes.

The second requirement of phototube operation is that the output stage must not be saturated. Tubes with low gain are picked for this application, and the supply voltage is kept as low as possible.

Electrical Circuits

The signal from the photomultipliers is about 80 volts during the time that the scan is on the paper, and nearly zero while it is off, but biased diodes hold the anode voltage near the 'on' value during the 'off' periods to reduce the large transient signals at the paper edges. Two photomultipliers are used. Each has a pre-amplifier, an amplifier, and a discriminator. The discriminator, a conventional Schmitt circuit[5] gives an output only if the signal is above a certain value. It passes pulse peaks which are due to flaws in the paper or due to noise in the phototubes. A 7-microsecond delay line in one channel, after the discriminator, brings the output of the leading tube back in phase with the other. The outputs of the two discriminators go to a coincidence circuit which passes a pulse only if a pulse arrives simultaneously from both channels. The probability is that coincident pulses are due to flaws in the paper rather than to random noise in the phototubes.

The output of this coincidence circuit contains pulses which are derived from the signals due to the edges of the paper. These are removed by a second coincidence circuit, or gate circuit, which requires a blanking square wave to come on just after the scan gets on the paper, and drop off just before the scan leaves. This square wave is produced in an auxiliary circuit as follows. The current in the photomultiplier suddenly changes as the scan comes on the paper, and this generates a voltage pulse, which triggers the square wave generator. This square wave holds the "gate" open while the scan is on the paper. The machine operator must adjust a calibrated dial, so that the width of the square wave matches that of the paper being handled. A block diagram of these circuits is shown in Fig. 6.

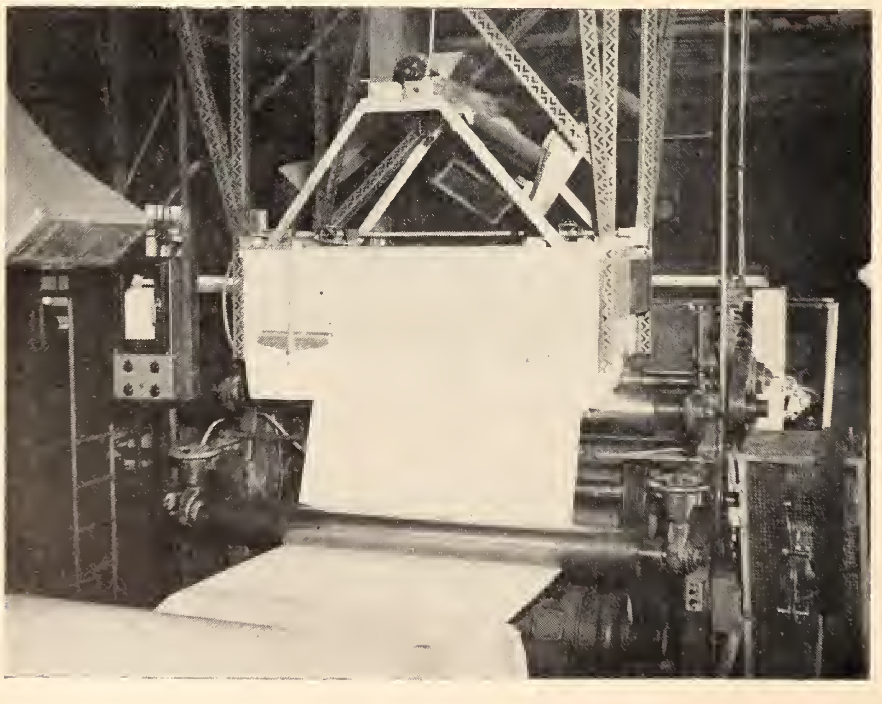
As has been noted before, the mercury vapour lamps are sensitive to variations of bulb temperature and line voltage. The light intensity changes approximately 3% for a 1% change in line voltage. As variations in the average output of the photomultipliers cannot be tolerated, the voltage at the dynodes of the photomultipliers is regulated by feedback to keep the output of the photomultipliers constant. Line voltage stabilizers improve the performance if variations of the supply voltage are large.

Final Model of the Detector

A flaw detector has been installed in a fine-paper coating mill. The scanner is set at the input to the cutter, which cuts the rolls of paper into sheets. The paper is scanned in a continuous strip, as it goes over a roll, but is sorted after it has been cut into sheets. A memory device remembers at which point on the roll of paper a flaw has been detected, and on what sheet the flaw is after cutting. This is necessary so that the sheets with defects can be removed some time after they are cut. The time delay is not constant, but depends on machine speed and sheet length.

The lights and their reflectors are enclosed in a box, suspended above the paper as it goes into the cutter, and are shown in Fig. 7. The rotating mirrors and the motor that drives them, the lens system, photomultipliers and preamplifiers are mounted on the top of the box, on a framework made of aluminum angle and channel.

Fig. 7. Paper Flaw Detector — Mill Installation — Scanning Unit



To the left of this scanning unit, as shown in Fig. 7, is the control box. This has switches for turning the electronic equipment off or on, dials for adjusting system parameters, and a recording meter which indicates whether the machine has been adjusted correctly or not. The bottom right dial setting controls the bias of the "Blanking Circuit Generator" shown in Fig. 6, and determines the length of the square wave from it. If this adjustment is correct, the "Blanking Circuit Generator" will generate a square wave which rises just after the scan has come on the paper and falls just before the scan leaves the paper. Signals from the photomultipliers can pass the gate or second coincidence circuit, only while the square wave is present, so signals from the edges of the paper or beyond are not permitted to reach the output circuit. The two upper dials control the level of the input to the discriminators in each of the two channels. These determine the sensitivity of the flaw detector. The recording meter indicates the number of pulses per unit time which come from each discriminator, which is an indication of the sensitivity of each. In the absence of any signals due to flaws in the paper, it shows the number of noise pulses which are able to pass each discriminator per unit time. Because there are two electronic channels and only one recording meter, the meter reads from each channel for alternate two and a half minute periods. The recording meter indicates the setting of the discriminators, and can be used as an indicator while setting the discriminator level. It is also a check on the drift of the machine and keeps a record of whether or not the operator is adjusting it correctly.

The control room contains the line switch, ballasts for the two mercury vapour lamps, transformers to provide two phase power for the lamps from the three phase line, and a transformer to provide 115 volts from 575 volts. A cabinet contains two chassis which hold the circuits, and the +300 volt and the −1400 volt power supplies.

Performance of the Detector

The electronic detector of flaws in paper will operate at paper speeds up to about 300 feet per minute, and will actuate a relay to sort the paper into two piles. It has been designed particularly for first grade paper which is normally sorted by hand. It will pick out most of the spots, marks, etc., which are serious flaws in this grade of paper. For example, when the sensitivity was set quite low, 6588 sheets were sorted by the machine and then resorted by hand. The machine picked out 342 sheets which contained defects. It missed 11 sheets which had defects which were not serious and missed 1 sheet which should have been removed.

It has certain limitations. It will detect only the larger creases and not the fine cuts. In order to be sure that it will detect all flaws, the setting must be over-sensitive. For example, in an order of paper with 3% defective sheets, the machine sorted out 10%. This means that the rejected sheets should be sorted again to reclaim the acceptable sheets. This is not serious since it is far cheaper to sort 10% of the paper than 100%, and even with hand sorting this must be done with double-size sheets to reclaim the good half of the sheets. Since it has been designed particularly for first grade paper, it is not ideally suited for sorting lower grades of paper. It rejects sheets with dirt marks, which may be acceptable for this type of paper, and if an order is particularly dirty the work of reclaiming the rejects is greater.

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1,966,243—1934 Hanna — Light spot scanning with rotating mirrors.

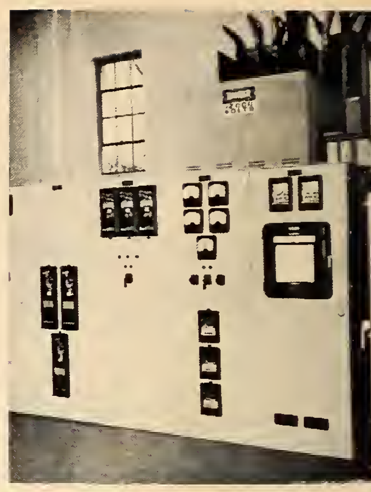
2,244,228—1941 Westmann—Looks for slime holes through paper.

2,395,482—Hurley — Photoelectric inspection with reflected light.

2,425,347—Schmitt—Testing of mica by voltage breakdown.

INSTRUMENTATION IN INDUSTRY

WATERWORKS AND SEWAGE



A 12 Kv. metal-clad structure at the McTavish Pumping Station.

IT WAS evident from remarks contained in the answers to the *Journal's* questionnaire that the concept of instrumentation as applied to automatic control and regulation of waterworks and sewage systems is in a very early stage of development in all but the largest centres. One or two respondants spoke of planned projects incorporating complete remote supervision, closed loop television supervision, automatic control of chemical feeds, automatic control of pressures and flow rates and a variety of automatic warning signals; but it was generally conceded in most cases that instrumentation involved the provision of fundamental parameters for manual operation and the provision of continual records of operation for operator's analysis.

The survey showed, however, that those responsible for waterworks and sewage in Canadian cities and towns are keenly interested in the latest developments in automation as applied to their field of activity. There was a great deal of interest expressed in automatic or semi-automatic control of pumps, filters, feeders and distribution systems through the use of various special sensing devices.

It is interesting to note from the literature on the subject that rapid strides have been made in recent years in the development of newer and better sensing devices, or transducers, which are essential to continuous automatic control work. The early experiments of Faraday, in which he tried to measure the flow of the Thames River by applying his theory of electromagnetic induction has been dusted off, and has resulted in very accurate and very versatile magnetic flow meters. In the transducer field, work is being done on a promising device to determine conductivity as it relates to coagulation reaction. A sensing device which relates fluoridation control to conductivity has also been developed, and many others are in various stages of investigation.

Those interested in the extension of closed loop, self-correction control systems realize that their success or failure is closely related to their ability to develop and provide simple, reliable sensing devices which can provide the necessary error signals for conventional and reliable servomechanisms. Increasing emphasis is being given to electronic control loops, as they minimize the problem of maintaining and replacement due to mechanical wear. An important factor in this trend has been the work done to improve reliability of electronic devices.

While there was little direct comment from those responding to the questionnaire, it appeared that the elaborate instrumentation used for fluorine feed into water supplies has functioned very satisfactorily in all cases, and the main comment seemed to relate to its high capital cost.

In all cases, emphasis was placed on the need for extreme simplicity, durability and ease of operation for all instruments used in water and sewage installations.

Power for Water and Sewage Plants

In most cases power requirements for plant operation was purchased from public utility power companies, but in several cases, and particularly in the smaller installations, some source of stand-by power was available.

Approximately 20% of those responding checked consumption of electrical power with their own instrumentation, and only four of those responding maintain separate steam plants for heating or power.

An interesting note with regard to steam is the use of steam provided as a by-product of sludge disposal in those plants utilizing or planning to utilize the atomized suspension technique or the high-pressure Zimmerman process. In each of these processes a wet combustion of the organic material present results in useful amounts of steam. The minimum solid content in the sludge must be 3-4% to support combustion, and the solid content should be more in the order of 6-8% to produce sufficient heat for power use. At least one plant has been built utilizing the atomic suspension technique, and some others are contemplating trying use of the Zimmerman process, which uses lower temperatures, but much higher pressures in its operation.

Uses of Instrumentation

As indicated in the introduction, very few plants in Canada are using fully automatic, self-regulated control systems, and therefore instrumentation is largely a matter of display and recording instruments. In those cases where servomechanism systems are used, pneumatic systems were indicated in more instances than electronic systems.

The most used application of instruments is to provide a continuous record of operations, followed by regulation of pressure or flow, achievement of better quality, provision of central supervision and economization in the use of fuel. In a few cases instrumentation was used to effect a reduction in the labour force, but this did not appear to be a major factor in waterworks and sewage plants.

The problems associated with waterworks and sewage plants almost invariably are reduced to those involving measurement of flow or pressure, provision of supervisory warning signals, and provision of records for analysis.

Who Determines Instrument Requirements

Most respondants determine their requirements through their own employees, but a considerable number use the services of consultants. As is usually the case, there is very often a combination of two, and about 20% of the organizations which replied, instrument requirements were determined largely through the services of firms supplying or manufacturing the instruments.

Specification of instruments is almost invariably handled by the waterworks engineer or his staff. The actual purchasing is also done by the engineering department in an overwhelming majority of cases, but in those which did not handle purchases in this way, there was a wide divergance in procedures.

Servicing of Instruments

Servicing of instruments is usually done by waterworks and sewage employees, or service is purchased as required, with approximately an equal number of respondants using each system. Only in about 10% of the cases reporting were service contracts with suppliers or independent companies used.

On the question of preventative maintenance programs, approximately one half have them, and one half do do not. There was no noticeable distribution among the replies, both large and small installations appeared on each group.

Most of those replying keep a stock of spare parts which has been built up through their own experience with various classes of instruments. The next most popular system for provision of spare parts was through lists recommended by suppliers of equipment, and this was considered to be very good, provided the supplier took the "long view" and resisted the temptation to increase contract figures with unnecessary material. Very few kept stocks of replacement units, and only two reported that they maintained no stock of spare parts for their instruments.

Special Features of Instruments

Most of those reporting stated that they were not interested in instruments incorporating optional plug-in features; only five respondants found such instruments suitable for their use. These represented larger installations, and probably are indicative of the fact that closed loop electronic control systems are not in general use at the smaller centre. The optional plug-in feature was found to be useful for maintenance, and for adaptability when changes or improvements are to be made.

In almost every case there was a preference for standard commercial lines of instruments, and in only a few cases did respondants show an interest in modifying standard lines to adapt them to their specific use. None of the respondants required instruments built to their own specifications.

In this group of organizations, as in almost all of the previous groups surveyed in this series, there was considerable emphasis placed on the need for simplicity and reliability. Respondants referred many times to the problems of training and maintaining adequate maintenance staffs, and of the new orders of magnitude of troubles, when they occur, in a plant which is fully instrumented. Apparently this is a factor which should be given serious attention by instrument designers; the users are willing to sacrifice a few orders of operational effectiveness in the interests of simplicity and reliability. They are afraid of gadgets and of systems which are hard to adjust, maintain or align.

The Financial Picture

Many organizations answering the questionnaire did not indicate whether they purchased or leased their instruments, but those that did indicated that, as might be expected, the great bulk of instrumentation is purchased outright. Total capital investment in instrumentation equipment ranged from under $3000 to over $500,000. Approximately one half of those reporting owned instrumentation in the range from $5000 to $25,000.

Annual maintenance costs varied widely among those reporting, from $35 to $50,000. Approximately one third of the respondants failed to answer this question, but it is interesting to note that the bulk of those who did, reported annual maintenance cost in the range from $500 to $5,000, and somewhere in the centre of this range would probably be the figure for a medium-sized plant.

Total capital investment in instrumentation during the past five years ran from $1,000 to $100,000. None of the very large centres reported this figure, and the $100,000 figure seemed about average for a city of 40,000-60,000 population.

General Comments

The excellent response to the questionnaire indicated a high level of interest in the subject of instrumentation in the water and sewage field. Some engineers expressed considerable dissatisfaction with the current rate of progress towards better instrumentation in many of the plants, and there was an expressed opinion which left the feeling that there will be a great deal of advancement in this field in coming years.

Specifically, in the field of water purification and distribution there is a great deal of interest in automatic systems to monitor the content of various organic and inorganic impurities, and to apply the correct degree of the appropriate remedy to maintain the water within pre-determined limits of purity. Automatic reversing and cleaning of the various high capacity filter systems now being developed, and automatic monitoring of chlorine and other chemical additions are only partly in hand, and there is much more work to be done. In distribution systems, there is interest in better automatic equipment to equalize pressure and control booster pumps, to provide warning and safety signals for leaks and flooding, and to control surges and fluctuations in large systems.

Sewage engineers are interested in better flow meters, pressure recorders, temperature recorders, and level recorders. They want automatically controlled sludge and circulating pumps, chlorine gas feeders, samplers, anti-foaming devices and samples.

Although most of Canada has no serious problem in water supply, there is one notable exception in southern Ontario where a lowering water table and increasing demand through increased industrialization and population is causing some concern. There is a good supply of fresh water available, but extension systems will be required to handle and distribute it, and there may be a day not too far in the future when the water table level will be maintained by a large percentage recovery of properly treated sewage. All of this points to more comprehensive and complicated water and sewage works, and seems to point to a bright future for advocates of advanced instrumentation in this field of activity.

ABSTRACTS

THE PERFORMANCE OF GALVANIZED (1 OZ./FT.^{2})* AND ALUMINIZED (ARMCO TYPE 1) STEEL SHEET IN VARIOUS CANADIAN ATMOSPHERES

THIS NOTE RECORDS the time to rusting of 1 oz./ft.^{2} (10 ¾ oz. in the trade) hot dip galvanized steel sheet and 0.040 in. Armco Type 1 Aluminized steel sheet in the atmospheres prevailing at six Canadian sites. The work was part of a large scale atmospheric corrosion test program undertaken by Aluminium Laboratories Limited in 1945.[1]

Galvanized steel sheet can be purchased with varying weights of zinc coating and it has been shown that its life depends almost directly on the thickness of zinc. The bulk of such galvanized steel sheeting sold in Canada is made to A.S.T.M. specification A 361-55T which includes provision for a triple spot check of thickness to a minimum of 0.90 oz./ft.^{2} and a single spot test minimum of 0.80 oz/ft.^{2} determined on an area of 5.06 in.^{2}. (ASTM A 90-53).

The material for testing was purchased from a Canadian sheet metal supply house in the form of flat sheet. It was cut into 6 x 8-in. panels for exposure. The zinc coating weight was determined by weight loss on stripping in inhibited hydrochloric acid and was found to be 1 oz./ft.^{2} (both sides). This corresponds to an average thickness of zinc of 1 mil. per side. A number of metallographic cross sections was examined under a microscope to determine uniformity of coating which was found to be in the range of 0.7 to 1.5 mil. with an average of 0.9 mil, in good agreement with the value obtained by stripping.

To check further the uniformity of coating a number of readings was taken with a *Drewitt* thickness gauge, which is equipped with a fine drill that penetrates the soft coating and stops on reaching the hard base metal. A dial gauge indicates the depth of travel (i.e. the thickness of coating). Five readings were taken on each side of six panels. The average thickness found was 0.95 mil, covering a range of 0.4-1.4 mil, which is in reasonable agreement with the results of other methods.

To prevent rusting of the bare steel at the sheared edges of the test specimens a quarter inch band of paint was applied by dipping. This included one coat of zinc chromate wash primer and two coats of aluminum-pigmented vinyl lacquer. This completely prevented edge rusting in all cases.

Five such panels were exposed at six Canadian test sites, all exposures being made over a period of about one year (December 1948 to February 1950). The specimens were held in porcelain insulators and faced south at an angle of 30° to the horizontal.

Single panels were removed from each site after varying exposure periods so that the progress of breakdown of the zinc coating could be followed. The main consideration was to ascertain as closely as possible the time period at which definite rust patches appeared, indicating loss of coating protection in these areas. The removal dates varied considerably from site to site for this reason, depending on the corrosivity of each location.

Shortly after these exposures were made, hot dip aluminized steel became available commercially and it was of obvious interest to compare the relative performance of the two coatings. A supply of Type 1 aluminized steel, produced by American Rolling Mills Company (*Armco*), was obtained, and sets of panels similar to those described for the galvanized sheet were exposed at the same six locations. This particular product is specified as having a 1 mil coating of an Al-Si alloy. The actual coating weight was determined by weight loss after stripping a panel in 10% NaOH and was found to be approximately 0.5 oz/ft.^{2} (both sides) which corresponds to an average thickness of 1 mil per side. Readings were also made by the *Drewitt* thickness gauge on five panels, the average thickness found over 10 measurements on each being 0.9 mil, ranging from 0.7 to 1.0 mil indicating a quite uniform coating. Exposures of aluminized panels were made from 1-2 years after the galvanized specimens had been set out. Single panels have now been removed from each of the sites, after time periods of 1, 2, 3 and 5 years. The fifth specimen will not be removed for 10 years or more, depending on its condition at each of the sites.

The table summarizes the time periods at which definite rusting first appeared on both galvanized and aluminized panels and the time periods to complete rusting of the upper surfaces, where this occurred. The test sites are listed in decreasing order of their corrosivity to the zinc

*1 oz./ft.^{2} (both sides) by actual measurement.

Test Site	Type of Atmosphere	*Galvanized*			*Aluminized*		
		First Rusted Areas		*Complete*	*First Rusted Spots*		*Complete*
		*Upper**	*Under***	*Upper*	*Upper**	*Under***	*Upper*
		(*Years*)	(*Years*)	(*Years*)	(*Years*)	(*Years*)	(*Years*)
Halifax, N.S.	Industrial-Marine	2.7	3.5	3.5	nil (5.0)	>5.0	>5.0
Toronto, Ont.	Industrial	3.0	5.0	5.0	nil (5.0)	>5.0	>5.0
Montreal, Que.	Industrial	3.5	5.5	5.0	nil (7.0)	>7.0	>7.0
Cape Beale, B.C.	Marine	5.0	nil (8.0)	>7.0	1.0	1.0	>5.0
Vancouver, B.C.	Mild Industrial	8.0	nil (8.0)	>8.0	nil (5.0)	>5.0	>5.0
Kingston, Ont.	Rural	nil (8.0)	nil (8.0)	>8.0	1.5	2.0	>7.0

* Skyward Surfaces   ** Groundward Surfaces

coating. Galvanized panels still remain on test at Kingston where no rusting has been observed to date.

On all panels the paint system on the edges is still providing excellent protection, the only breakdown occurring at the points of contact of the holding insulators. One point of general interest is that rusting of the galvanized coating on the upper surfaces started at the bottom of the panels and proceeded upwards. This effect is undoubtedly due to the runoff of moisture whereby the lower portions of the panel remain wet longer than the top areas.

Where rusting occurred on the Type 1 aluminized panels, it took the form of small pin point rust spots which appeared fairly early after exposure. However, in the ensuing period there has been little increase in corrosion and the aluminum is providing good overall protection to the underlying steel. The early appearance of these rust spots is due to a degree of porosity in the coating whereby micropores occur at which the steel rusts quickly. The aluminum surrounding these pores, however, provides cathodic protection and further damage is held in check. The main result is to detract from the appearance of the sheet without any serious corrosion or metal loss. More recently a second type of aluminized steel (Type 2) has been marketed which has a 2 mil coating of commercially pure aluminum on the steel base. Sets of specimens of this product have now been exposed at the same sites but no test results are available as yet. Indications are, however, that this is an improved product which solves the rust-spotting to which the first type is susceptible in some atmospheres.

The results clearly indicate that highly polluted industrial atmospheres are the most detrimental to galvanized coatings. Initial rust occurred in less than 3 years at Halifax, 3 years at Toronto and 3½ years at Montreal. These figures are in good agreement with the 3½ year life reported for a 1 oz./ft.^{2} coating exposed at Sheffield, England,[2] and with the A.S.T.M. average figure of 3½ years as the life of zinc coatings of similar thickness in a number of industrial atmospheres.[3] Longer protection for the base metal (approximately 8 years) was obtained at Vancouver because this site is only mildly industrial in nature. It is apparent that the aluminum coating has greatly superior corrosion resistance to industrial atmospheres.

It is interesting to note that the zinc coating performed somewhat better in a marine atmosphere giving protection to the underlying steel for over 7 years at Cape Beale. Marine atmospheres produce more pin point rusting of the aluminized sheet than industrial atmospheres but corrosion is still minor after 5-7 years.

In the rural atmosphere at Kingston, the galvanized panels are scarcely affected other than being darkened slightly after 8 years. Results of the A.S.T.M. tests to date show no failure of galvanized coatings of 1.5-3 .2 oz./ft.^{2} thickness after 23 years exposure to rural atmospheres.[3] The pin-point rusting of the aluminized panels which occurred early appears to have been almost entirely arrested and there is little increase in corrosion after 7 years over that present after 2 years.

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NEXT ISSUE

of

TRANSACTIONS

VOL. 3, No. 2   JULY

INTERNATIONAL NEWS

BRITAIN

SCIENTIFIC AND TECHNICAL DEVELOPMENTS, as reported in *Commonwealth Survey,* March 17, 1959, are summarized as follows:

The 'Swallow' Aircraft Project

On February 23, 1959, the Minister of Supply, Mr. Aubrey Jones, announced in Parliament that he had made an agreement with the United States authorities and with Vickers for a joint research programme designed to prove the potentialities of the Swallow aircraft concept of variable geometry.

This principle, on which Dr. Barnes Wallis of Vickers has been working for some years, incorporates a pivoting system allowing the position of the wings to be varied so as to give the best characteristics for different speeds and phases of flight. Take-off and landing could be accomplished at slow speed, with the wings almost at right-angles to the fuselage; for high-speed cruising flight, the wings could be swept right back. It is thought that the design could be developed for civil or military aircraft.

The minister said that a series of tests and engineering studies would be undertaken, partly at Vickers, partly at the Royal Aircraft Establishment (Farnborough), and partly in US Government research establishments.

Progress with Flexible Barges

The flexible barge invented by Professor W. R. Hawthorne in 1956, and developed under the sponsorship of the National Research Development Corporation (NRDC), made its first commercial voyage in February 1959. It successfully delivered a cargo of 10,000 gallons of kerosene from the Esso refinery at Fawley, Hampshire, to Newport, Isle of Wight. Though experiments are in progress in Germany, this is thought to be the first commercial trip by this new form of transport for water-borne liquid cargoes.

The barge, which is an envelope made of nylon coated with synthetic rubber, was towed by a 45 horse-power launch and completed the 10-mile voyage in 2 hours, after which the cargo was pumped into storage tanks in 65 minutes. It was then filled with carbon dioxide and towed back. For commercial use it is intended to wind the vessel on to a reel and stow or tow it after discharge of the cargo.

These kinds of barges were originally intended for cheap ocean carriage of oil, but the emphasis is now shifting towards the carriage of liquids on inland waterways. Two vessels have been ordered for trials, one by an oil company and one by a shipping company. Both are for use in West Africa, an area better served by river than by road, and where such vessels consequently appear to be of great potential value.

The vessel used for the voyage was 100 feet in length, carried 40 tons of oil and cost just over £3,000. The company formed to develop the project, Dracone Developments Ltd., is now building one twice this length with a cargo capacity of 350 tons.

Improved Radar

In the debate on the Air Estimates on March 5, 1959, the Secretary of State for Air, Mr. George Ward, mentioned improvements which had been developed in radar. With present radar equipment, pictures could be taken which enabled airfields to be identified and runways accurately measured. With the improved equipment being developed for the Victor bomber, it should be possible, under favourable conditions, to make an estimate of the number of aircraft assembled on an airfield.

The Victors would be able to cover an area equal to the whole of the Mediterranean in a single radar reconnaissance sortie by one aircraft, and they could give a count of the total number of ships in the area. As another example, a radar map of an area of the size of the United States could be made in one sortie by only four aircraft.

The Isaac Newton Telescope

The Admiralty announced on February 23, 1959, that financial approval had been given to proceed with the construction of a large telescope known as the Isaac Newton Telescope, which will be erected in a special building in the grounds of the Royal Greenwich Observatory at Herstmonceux Castle in Sussex. This project was sponsored by the Royal Society.

The new telescope, which will have a 98-inch aperture, will weigh approximately 100 tons and be some 30 feet in length, will be the largest optical telescope in the United Kingdom. It will be used by visiting astronomers as well as by the staff at the Royal Greenwich Observatory, Herstmonceux, where the largest existing telescope has an aperture of only 36 inches diameter. The cost of the whole project, including erection and preparation of the site, is estimated at £660,000 at present prices, and will take 5 to 6 years to complete. Expenditure will be shared equally between the Treasury and the Admiralty.

British National Committee on Space Research

Britain's upper atmosphere research programme with the *Skylark* project, which has been the concern of the Royal Society's Gassiot Committee, will in future be a responsibility of the newly formed British National Committee on Space Research. This committee, which held its first meeting at the Royal Society on March 4, 1959, was set up to co-ordinate British research activities and to co-operate with the Committee on Space Research (COSPAR), formed by the International Council of Scientific Unions to arrange international collaboration on scientific experiments conducted in space. At its first meeting, the new national committee, under the chairmanship of Professor H. S. W. Massey, considered a report of British observations of earth satellites, and the theoretical work carried out on the motions of satellites in orbit.

A joint programme of upper atmosphere research with *Skylark*, arranged by the Gassiot Committee and the Ministry of Supply, began in 1958. The firing of *Skylark No. 5*, which reached a peak altitude of about 93 miles, on May 20, 1958, and *Skylark No. 6* on August 2, 1958, completed the initial phase of the development programme. The Gassiot upper atmosphere research programme began on April 17, 1958, when *Skylark No. 7* was fired. On June 19, 1958, *Skylark No. 9* was fired, on the occasion of the IGY World Rocket Interval, and reached a peak altitude of about 103 miles.

New Research Station for Scotland

It was announced by the Ministry of Supply, on February 17, 1959, that a research station to study the effects of the aurora on radio reception is to be set up on the site of a former radar station at Hillhead, near Fraserburgh, in Aberdeenshire.

This research, part of a programme of ionospheric studies, will be undertaken by the Stanford Research Institute of the United States, in collaboration with scientists from the Royal Radar Establishment of the Ministry of Supply. Observations will be made with a large parabolic reflector, about 140 feet in diameter, brought from the United States. The experiments are expected to start in the late spring or early summer, and will last one or two years. The cost will be borne by the Stanford Research Institute.

New National College of Agricultural Engineering

The Ministry of Education announced in February, 1959, that a new National College of Agricultural Engineering was shortly to be established by the ministry, near the National Institute of Agricultural Engineering at Silsoe, Bedfordshire, in co-operation with the agricultural industry.

GERMANY

THE NEW LINER "BREMEN", will go into service on the North Atlantic route later this year.

The new 32,000-ton "Bremen" is the fifth liner to carry this name in the past 100 years. Last year the Norddeutshe Lloyd shipping company decided to buy the old French troop transport ship "Pasteur" and convert it into a modern turbine-engined luxury liner, at total cost of $22.8 million. The new "Bremen" was refitted to carry 1,200 passengers. Among the particular features are 60,000 hp. engines, a single smokestack having smoke preventing equipment, and an air-conditioning system.

TOWN GAS FROM OIL. The Hamburg Gas Company, one of the largest municipal gas works in Germany, has effected useful combination of gas and oil. The company made 411 million cubic metres of town gas last year, of which 73 million cubic metres came from a new cracking-plant at Tiefstaack. For this purpose 47 million cubic metres of oil refinery gas was supplied by Esso of Hamburg-Harburg, a Standard Oil subsidiary. Another 8 million cubic metres of refinery gas were stored in an underground container at Reitbrook near Hamburg as a reserve for peak-hours.

Another cracking-plant at Boostedt in Holstein processed 1 million cubic metres of natural gas from the neighbouring oilfields of Plon and Barmstedt and made 2½ million cubic metres of town gas from it.

Other German gas works too have built crackers, or are planning to do so. Hamburg has started the second Lurgi cracker at Tiefstaack, and the plant can now make 800,000 cubic metres of gas a day.

AN ORE DRESSING PLANT, the second Krupp-Renn plant of this kind to be built in West Germany since the war is under construction at Essen-Borbeck. The plant, which will process low grade ores from Germany and abroad, is part of the West German steel industry's efforts to become gradually more independent of scrap supplies and to secure a steady supply of raw materials.

Called "Rennanlage Rhein-Ruhr", the plant is being constructed by Fried, Krupp, of Essen, and will be jointly operated by nine West German steel concerns. The first of its six kilns is to be ready to go into operation in mid-1959, the other five in 1960. The plant will eventually have an annual output capacity of from 420,000 to 450,000 tons of iron.

ITALY

PETROCHEMICAL PLANT. Construction began in March on a $95 million petrochemical plant being built by Montecatini at Brindisi. Estimated time for completion is three years.

With a planned capacity of 700,000 metric tons of chemicals per year, and storage tanks with a total capacity of 14,000,000 cu. ft., the plant will be the seventh and largest in the Montecatini group for processing hydrocarbons; the largest in Italy. In addition to several plastics, including polyethylene and Montecatini's new "MOPLEN" isotactic polypropylene, polymers for synthetic fibers, aldehydes, alcohols and organic solvents will be produced utilizing a minimum of 1,300,000 metric tons of raw materials annually.

The plant was described as a large scale translation to industrial application of concepts of stereospecific catalysis discovered by the Italian scientist, Professor Giulio Natta and developed by Montecatini.

A 1200-acre plot near Brindisi will serve as the plant site. Twenty miles of roadway and six miles of railroads will be built within the plant area to facilitate handling of raw materials and finished products.

A thermo-electric plant will also be built to supply the power requirements of the plant making it completely autonomous. An estimated 300,000,000 kw. hrs. of electricity per year — twenty times that consumed by the entire town of Brindisi — will be needed. The plant will use about 2,000,000 tons of steam annually. Upon completion, the plant will employ approximately 2500, with another 1500 employees engaged in activities directly related to its operation.

At least two thirds of the raw materials and finished products will be transported by sea, increasing the annual tonnage handled by the port of Brindisi by more than 1,500,000 metric tons.

Montecatini began its petrochemical activities in 1951. It operates petrochemical plants at Ferrara, Novara, and Terni.

VENEZUELA

CREOLE FOUNDATION PRIZE. A prize is offered by the Creole Foundation, in order to stimulate interest in research work related to Venezuela in the fields of natural, physical and social sciences. It is given for the best work on Venezuela in any branch of those sciences in accordance with certain rules.

It consists of the amount of $10,000, and a diploma, to be given to the author of the work selected through competition. It will be given every two years in Caracas, beginning October 17, 1960. Persons of any nationality may participate.

The works must be received by December 31, 1959, for the first competition. Copies of the regulations may be obtained by writing to the Embassy of Venezuela, The Roxborough, Ottawa, Ontario.

UNITED STATES

WHAT IS BEING DONE TO MAKE FLYING SAFER and more efficient, was described by the Air Transport Association in a recent Newsletter.

As part of its airways modernization program, the FAA is installing enroute surveillance radar with a 200-mile range. In adequate number, this long-range "eye" would have the ability to do much to increase air traffic capacity and air navigation coverage.

Long range radar has the potential to decrease delays in aircraft arrivals and departures, in addition to providing a better utilization of the airspace. Another important function of long-range radar is that it can help aircraft to avoid bad weather.

During the latter part of 1958, the CAA (prior to going over to FAA) and the U.S. Air Force's Air Defense Command set up a Radar Advisory Service to provide separation of civil jets from all other aircraft flying above 24,000 feet.

Essentially, the service employs the available FAA long-range radar, plus radar of the Air Defense Command network. FAA employees are used at the Air Force radar facilities to monitor the separation of civil jets from other traffic in the area.

Initially, this radar coverage was available only to jets operating in the Northeastern states and between New York and Miami. However, in late January of 1959 the service was extended to transcontinental routes. This means that as the scheduled airlines introduce jet aircraft into their transcontinental operations, radar advisory service will be provided.

A new FAA facility designed to centralize and speed up reports on near-miss incidents was recently announced by the FAA. The facility became effective on March 2.

Known as the Central Reporting Office, this new FAA facility will serve as a "clearing house" for all reports on near misses from FAA control stations around the country.

A joint civil/military program for studying ways to modernize the nation's aviation weather system was recently announced by the FAA. The program calls for establishment and execution by the Department of Defense, Commerce and the FAA of a unified research and development effort to produce a weather service system compatible with requirements of a modern system of aviation facilities.

"This would be a big step toward increasing the capacity and efficiency of the nation's air traffic control system," the FAA announcement points out.

Under the plan, the existing weather system and equipment development projects would be integrated with the Air Force semi-automatic system. Air navigation and traffic control developments also would be related. Initial step in the program would be taken by the Air Force.

Elements of a system under development by the Radio Corporation of America to increase driving safety on the nation's roads will be installed this year at the FAA's experimental center at Atlantic City to help solve the problem of jet-age air traffic at busy airports.

"Conceived as a means of sensing the presence of automobiles on a highway, the technique is adaptable with equal effectiveness to the detection of aircraft moving along runways and taxiways," an RCA spokesman said.

At the heart of the system is a series of wire loops and small detector units buried in the pavement along the path followed by aircraft on the ground. The FAA bureau of Research and Development envisions an eventual system under which an arriving airliner, for example, will be under electronic control from the time its wheels touch the runway until it is parked and discharging passengers.

The January, 1959 issue of Aircraft Industry Association's *Planes* said that the safety, efficiency and comfort of jet aircraft stand to be further increased by a revolutionary new liquid-cooled brake system utilizing what is called a "heat exchanger." This thermodynamic device is essentially a water boiler. A common anti-freeze mixture is circulated behind the friction surfaces of the brakes, picks up the heat, and transports it to the heat exchanger where it is transferred to water. Temperature buildup in the critical wheel and brake area is thus reduced by as much as 1,500 degrees.

Operating at low temperatures reduces the possibility of tire blowouts and brake failures. Brake noise and vibration are almost completely eliminated.

With today's high-speed, long-range aircraft, compass accuracy is of the first importance. A method of calibrating airborne compass systems has been developed under sponsorship of the USAF's Wright Air Development Center, Dayton, Ohio.

The Air Navigation and Traffic Control Division of the Air Transport Association has recently completed a study of some of the operational and technical characteristics, on a comparative basis, of the Decca and VOR/DMET navigation systems.

Copies of the study may be obtained by writing the Air Transport Association, 1000 Connecticut Avenue, N.W., Washington 6. D.C. Attn: Director of Information.

It is more than six times as safe to travel on U.S. scheduled airlines as to travel by automobile.

Private car and taxi fatalities during the five-year period ending 1957 (1958 figures were not yet available) were 2.7 per 100 million passenger-miles. Rate for the domestic scheduled airline industry was .42 for the five-year period ending 1958.

The airlines' safety trend shows continuous improvement. Fatality rate for the total U.S. scheduled airline industry was 2.55 per 100 million passenger-miles for the five years ending 1943. It dropped to 2.04 during the next five years. The rate was cut in half – to one fatality per 100 million passenger-miles–in the five-year period ending 1953. Statistics for the past five years (ending 1958) show an almost three-fold improvement, with the rate down to .38.

ISRAEL

RECENTLY ACQUIRED INSTRUMENTS now in operation at the Solar Physics Laboratory of the Technion bring the sun and its activities appreciably closer to earth for study.

Among the new acquisitions is a telescope fitted with a H-alpha filter. When fully installed it will enable the scientific viewer to observe, in hydrogen light, activities such as eruption flares on the surface of the sun. These are the phenomena which have a direct influence on the ionosphere level, which maintains radio wave propagations on the earth.

A coelostat solar spectrograph has been set up to measure turbidity in the atmosphere of the earth. This instrument displays a complete solar spectrum when aimed at the sun, and automatically follows the movement of the solar body in the sky. This equipment will serve as a basis for a survey aimed at measuring the penetration of various rays and will permit a check on the influence of these rays on public health and agriculture.

The equipment is located in the Albert Einstein Institute of Physics at Technion City. Plans are also now being made for an extension of the Solar Physics Laboratory on the roof of the building.

Prof. Kurt Sitte is head of the Division of Physics, and Assoc. Prof. Nathan Robinson is head of the Solar Physics Laboratory.

Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

THE ENGINEERING MANPOWER SITUATION

THE CANADIAN labour market for engineers in 1958 was affected by two important developments in 1957: firstly, the economic slackening after several years of sustained expansion and, secondly, the record net immigration of engineers into Canada.

According to the fourth professional manpower bulletin issued by the Department of Labour at Ottawa* the 1957 situation continued in the following year. The national economy did not expand at the 1956 rate, thus keeping down the rate of increase in demand for engineers. At the same time, the new supply almost reached the 1956 level. However, the most noticeable supply change in 1958 as compared with 1957 was the steep decline in the net immigration of engineers from the record level of the preceding year.

In early 1959 a general supply deficiency was no longer indicated, although universities and governments were still reporting great difficulty in recruiting engineers. Their lower salary scales compared with those in industry are probably the chief reason for this. Generally, demand and supply are fairly well balanced, but with a tendency towards a surplus, particularly of new and inexperienced engineers.

Net immigration of engineers is expected to be negligible over the next few years, whereas a large increase in the number of Canadian engineering graduates is foreseen. Expansion in the employment of engineers is expected to continue but at a much reduced rate. The moderate rate of economic recovery— in particular, of private investment—and probable changes in the defence program, are foreseen as limiting factors. A shortage of engineers might recur if there is any sharp expansion in economic activity, particularly if it is accompanied by a rise in private investment.

*"Recent changes in Engineering Manpower Requirements and Supplies in Canada"; Bulletin No. 4, January 1959, Economics and Research Branch, Department of Labour, Canada. Price 25 cents, The Queen's Printer, Ottawa, Ont., Canada.

The bulletin sums up the supply and demand situation for the periods 1955-57 and 1958-60 as shown in the following table.

Supply and Demand

	1955-57 (actual)	1958-60 (forecast)
Number of engineers graduating from Canadian universities	4,670	6,500
Approximate net immigration	3,285	500
Total new supplies	7,955	7,000
Net requirements	10,000 to 12,000	6,500

Upgrading

The two major sources of additions to the pool of engineering manpower are of course university graduates and net immigration: in 1958 graduates reached the highest number since 1951 while net immigration dropped to the lowest level in nine years.

A number of engineering positions are filled in Canada by men who have not obtained an engineering degree from a university. Some of these receive recognition by successfully passing examinations set by the appropriate provincial registering body. Others have neither qualified academically as engineers nor are they recognized by an engineering association, but they are considered as competent engineers at the professional level by their employers.

Only fragmentary information is available on the extent to which employers fill engineering jobs at the professional level with workers who have acquired their competency through work experience, periodic private study and informal learning. On the whole, they are an older group than the graduate engineers since they obtain their engineering status through years of informal training and experience. There are also probably a relatively large number of immigrants among them, including, for example, holders of Higher National Certificates from Great Britain.

There is some evidence that during a period of severe engineering shortages the number of non-graduate engineers increases, since employers will intensify the practice of upgrading and perhaps even reduce their hiring standards. Firms that have to build up their production schedules relatively quickly may find the experienced non-graduate engineer more immediately useful to them than the recent college graduate who, although possibly possessing greater potential, has to be trained for several months before being able to make any valuable contribution to the production process. An adequate supply of graduate engineers would probably have the opposite effect and reduce the willingness of employers to promote the non-graduate into a professional engineering job except for those who are outstanding in ability or experience.

On the recruitment side, an important new source of information has become available through the Department of Labour's Biennial Survey of Requirements for Professional Personnel, just completed. In the survey, replies were received from a very large proportion of Canada's employers of engineering and scientific manpower. The questionnaire contained a section on recruitment sources including upgrading. Employers were asked to indicate in quantitative terms the extent to which workers were upgraded to professional work level during 1956 and 1957 and on what basis. The returns showed that 339 were upgraded to professional status during the period and of that number, 41 had obtained a university degree subsequent to their original employment, 240 were upgraded by recognition of their experience and ability and 58 by obtaining membership in a professional association. The two latter figures combined were equivalent to 9 per cent of the total hirings of engineers and scientists during 1956 and 1957 by the employers surveyed. It must be remembered in this connection that this was a period of considerable shortage of engineers.

Employers' Expectations Change

Between 1956 and 1958 employers — especially in industry — considerably revised their estimates of their future requirement of engineers. In 1956 industry forecast an average percentage increase per year for 1956 to 1958 of 12.2 per cent, but in 1958 employers in the same sector predicted an annual increase of 5.1 per cent for the period 1958-1960.

Recruitment difficulties in 1954 and 1955 were reported by 61 per cent of employers in industry, 90 per cent of the colleges and universities, and 85 per cent of government agencies —compared with 22 per cent, 75 per cent and 58 per cent respectively reporting difficulties in 1956 and 1957. Employers in all three sectors expect this trend to continue: recruitment difficulty is anticipated by only 13 per cent of industrial employers, 61 per cent of the colleges and universities and 38 per cent of government agencies. Aeronautical engineering, followed by electrical, metallurgical and chemical engineering, were the fields reporting the greatest difficulty in 1956-1957, while mining, civil and geological engineering had the least. For expected recruitment difficulties from 1958 to 1960, three engineering fields stand far above the rest, namely aeronautical, electrical and metallurgical. These figures represent percentages of employers reporting or expecting difficulties, and are therefore subject to the limitation that one employer may be concerned with just a few engineering specialists while another's difficulties may arise from a need for dozens of engineers.

National Employment Service

National Employment Service figures are another clue to the changing labour market for engineers. Since the end of the Second World War, the Executive and Professional Division of the National Employment Service has been functioning as a nationwide employment exchange for executive and professional personnel, including engineers. Every month detailed statistics are available on the regular operations of the National Employment Service and these figures include, among other data, the number of applicants and unfilled vacancies at a given date. These statistics are broken down by region and occupation with data for engineers shown separately. To help assess the current labour market situation for engineers by means of these data, average ratios of vacancies to applicants in the engineering field for each year from 1950 to 1958 have been worked out. Examination shows that they range from 36 per cent in 1950 (or one vacancy for about three applicants) to 569 per cent in 1956 (or slightly more than five and a half jobs for every applicant), the second lowest ratio, 54 per cent, (or one vacancy for slightly more than two applicants) having been attained during 1958. On the basis of these figures, the period from 1955 to 1957, especially 1956, witnessed the greatest shortage of engineers of the nine years under review.

National Employment Service figures are also subject to limitations, but it is felt that they are reasonably meaningful in showing the general pattern of change in the labour market for engineers.

Since 1951, the National Employment Service has been surveying the major employers of professional personnel in Canada in order to obtain from them an estimate of the openings they expect to have the following spring for new graduates in different fields, including engineering. Except for 1951 and 1958, Canadian employers reported having more job openings for new graduates in engineering than the number of such graduates turned out by Canadian universities and colleges. The years 1956 and 1957 had the greatest number of job openings reported in excess of Canadians graduated from university in engineering.

Wages and Salaries

The trend of wages and salaries is generally assumed to reflect the changing relationship between supply and demand for labour. Increases in weekly earnings of workers as a whole and in engineering starting salaries followed each other very closely up to 1955. However, in 1955, 1956 and 1957 starting salaries for engineers rose at a much faster rate than industrial earnings. 1956 and 1957 were the two years when, as the preceding analysis indicates, Canadian employers experienced the greatest shortage of engineers since World War II. However, in 1958 starting salaries for engineers rose only slightly above the 1957 level while industrial earnings in general again increased significantly—confirming a relative slackening in demand for engineers.

Utilization of Engineers

The final section of the bulletin contains some pertinent observations on what may happen to the utilization of engineers when their supply comes into balance with demand or when an actual surplus develops:

"Employers finding it easier to obtain qualified engineers can afford to be more selective. They are in a position to hire and to retain on staff only the most efficient engineers for their enginering work. This in turn should result in a need for fewer enginers than would otherwise be the case. At the same time, still another result may occur when a fairly large surplus of engineers develops. The less efficient or less qualified engineer from the point of view of the employer, finding it more difficult to remain in or to obtain bona fide engineering employment, may, rather than join the ranks of the "out of work", accept jobs either without or with only a partial engineering content, thus leading to what could be considered to be "engineering underemployment" or "disguised engineering unemployment". A surplus of engineers in the labour market therefore may lead to contradictory results: the most qualified may be used more efficiently while the less able or less qualified may be used less efficiently. A surplus of technicians may also develop from this situation."

Such possibilities are seen as emphasizing the need to work toward successful job orientation by providing vocational guidance information and financial assistance to those students who, although most suited for an engineering vocation and desirous of entering such a profession, cannot afford to do so.

New Mining Industry

The first shipment of potash mined and refined in Canada was made to Canadian markets in March from the Saskatoon plant of Potash Company of America. Potash mining is a new Saskatchewan industry.

Mine and plant facilities costing $20 million, include the massive concentrator, crushing plant, warehouses, and general office.

Operating at capacity the plant will produce 600,000 tons of the finished product annually. The plant employs 200 people. Its annual payroll is in excess of $1 million.

Mining is carried on in a horizontal tunnel off the main shaft. A continuous miner is used in the mining operation. The ore is a mixture of potash, common salt and a small amount of clay.

FIRST UNIVERSITY NUCLEAR REACTOR

The opening of a privately owned atomic reactor at McMaster on April 10th places Hamilton's university in a unique position among Canadian institutions of learning. The nuclear reactor has clearly asserted its function as an instrument of peaceful research, and now takes its place as an academic installation in the quiet surroundings of the campus. The $2,000,000 project was financed by grants from Government of Canada research agencies, by the Hydro Electric Power Commission of Ontario and by contributions from private industry.

Housed in a circular (actually 15-sided) 72-foot high building, the 1000 kilowatt research reactor is of the "swimming pool" type, chosen for its inherent safety and adaptability to experimental work. The concrete, windowless reactor building is 82 feet in diameter with the lowest floor 17 feet below ground level. It has a firm foundation — a 140-foot wide, five-foot thick reinforced concrete slab which was poured in a single operation.

The reactor consists of a special concrete, tile-lined pool rising 35 feet above the experimental floor and extending through the second (operating) floor of the building. Its core—an array of thin sheets of aluminum and an alloy of uranium—is located 25 feet below the surface of the pool. One hundred thousand gallons of constantly purified water circulate around this core to provide a shield against radiation as well as remove heat and slow down the neutrons so that they can initiate fission in the U-235 atoms. Cadmium-lined boron control rods are used to draw off excess neutrons and regulate the fission process at the desired rate.

Core of fuel elements suspended from a movable bridge over the pool.

The availability of a nuclear reactor makes possible many research projects not previously feasible. For example, many of the most interesting radioactive nuclei are short-lived and can only be studied near the source. The properties of these nuclei can be more fully explored at McMaster.

Radiation produced by the reactor, or from radioisotopes produced in it, provides a fourth dimension for the chemist and chemical engineer. Chemical reactions are influenced by temperature, pressure and catalysts. Radiation, in many cases, acts like a catalyst and hence provides this fourth dimension. Chemists have studied the composition and behaviour of very large molecules to form long chain-like molecules which make up the plastics and synthetic rubbers. This process is called polymerization, and radiation is known to induce it at lower temperatures.

Mechanical engineers have studied engine wear and friction with radioactive piston rings. Neutron irradiation of the rings in a reactor yields radioactive iron. As the engine in which the rings are installed is operated, the weight of the iron that wears off may be detected down to 1/100,000 of an ounce by oil sampling.

The future holds promise for important studies in neutron diffraction by our physicists and metallurgists. This technique yields information about the structure of materials that will greatly assist in developing the new alloys and ceramics needed in this age of jet engines and rocket power.

Researchers in widely differing fields will be able to use the reactor. In addition to providing neutrons, gamma rays and isotopes to McMaster teams working in the physical and biological sciences, engineering and medicine, it will assist other research organizations wishing to develop new projects. It will also serve industry and aid in the teaching of nuclear science to students.

Building in the North

Special features of building in the Canadian North are dealt with in a new publication of the Division of Building Research, National Research Council, Ottawa. The technical paper "Building in Northern Canada"*, reports the recent quickening pace of construction in Northern Canada, demanded by mining development, the search for oil, and the decision to build the community now known as Inuvik, which will come into full use within the next year or two. Frobisher Bay will become a complete northern community, as a point on the Arctic trans-Atlantic air routes.

The factors that distinguish northern building from building elsewhere are the climate, the unusual terrain and the relative isolation of most building sites. Climate, the report explains, differs mainly in the duration of cold weather rather than in extremes of temperature, and the technical problems are not significantly different. But the climate does account for the short construction season, and for the presence of permafrost. And permafrost is a major technical consideration, requiring specific construction techniques in some conditions.

Distances, limited transportation facilities, lack of manpower, make the economic and logistic factors still more serious considerations.

Techniques, conditions to be expected, special northern requirements, transportation, supply, materials, and many other important points are discussed by authors R. F. Legget and H. B. Dickens.

Athabasca Oil Sands

The Alberta Technical Committee began meetings in April which will enable it to advise the Oil and Gas Conservation Board and the Alberta government on safety and other technical aspects of the proposed nuclear test in the Athabasca oil sands of Alberta.

Mr. S. Stewart, manager of the Canadian Division of the Richfield Oil Corporation, appeared before the committee to review the proposal. Dr. G. W. Johnson, test director of the Radiation Laboratory of the University of California, outlined for the committee results of five underground

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* "Building in Northern Canada", National Research Council, Division of Building Research, Ottawa, Canada, 50-page mimeographed booklet, $0.75.

nuclear explosions which had been carried out under his supervision for the United States Atomic Energy Commission. He will furnish the committee with scientific and technical information on these tests for further study.

Dr. G. W. Govier is chairman of the Alberta Technical Committee; the members are Hon. A. R. Patrick, Grant MacEwan, H. H. Somerville, D. A. L. Dick, George Garland, C. G. Garvenor, Dr. H. E. Gunning, D. R. Craig, and A. S. Manyluk.

The terms of reference of the Committee are

- To review the procedure proposed and scientific data now available and requirements for adequate assurance that: there would be no surface breakthrough or fissuring to the surface; the bulk of the radio-activity produced would be adequately entrapped in insoluble form; and there will be no significant radio-activity contamination of the oil or gas or of underground water.
- To review the technical and scientific data which should be obtained, before, during and after the test, if the test is approved, and to review other relative materials.
- To advise the Oil and Gas Conservation Board and the provincial government on the entire proposal.

What Goes On

Columbia River Discussions

The International Joint Commission, meeting in Montreal on April 30 and May 1, made progress toward development of principles on the apportionment of benefits resulting from a cooperative development of the Columbia River.

The discussions were directed to clarification of principles. Technical officers will analyze the information developed, and the Commission was to meet again in a month's time.

Organic Cooled Reactor for Canada

Atomic Energy of Canada Limited has awarded to Canadian General Electric Company a $600,000 contract for a design study and associated development of a nuclear power reactor, to be known as OCDRE (Organic-Cooled, Deuterium-moderated Reactor Experiment).

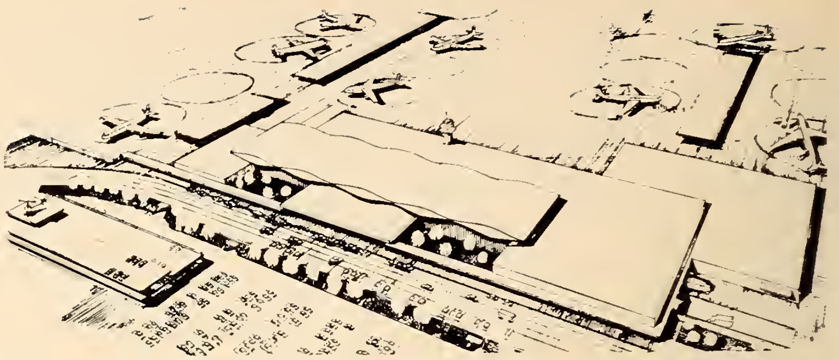
In this reactor, organic liquid, rather than heavy water, will be used to transfer heat from the uranium fuel to the steam generators. Heavy water is to be used as the moderator and the fuel will be natural uranium.

The growing interest in the use of organic liquids as reactor coolants is based on lower price, and the possible adaptation to small and medium size stations in more remote areas.

The decision to proceed with the design study resulted from discussions among members of the staffs of the Department of Northern Affairs, The Northern Canada Power Commission, and Atomic Energy of Canada Limited.

Organic coolants appear to offer means of reducing capital costs. Besides the saving in cost of the coolant, there is the additional advantage that a low pressure system can be used in the reactor, because organic liquid has a high boiling point. Organic liquids are much less corrosive than water at high temperatures and therefore more normal structural materials such as aluminum alloys could be used in the reactor.

On the other hand, organic liquids are affected by radiation and will require some continual replacement by fresh material. Furthermore, fuel costs in an organic-cooled reactor are likely to be higher than in a heavy water-cooled reactor.



Proposed terminal building for Vancouver Airport.

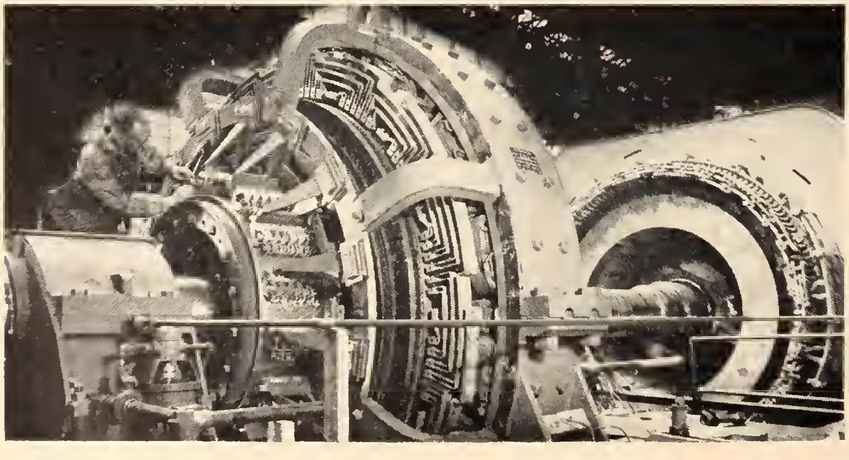
Vancouver Airport Proposal

The proposed $14 million passenger terminal for Vancouver's international airport is designed to cope with three times the traffic handled at Sea Island in 1958, according to a preliminary planning report submitted to the city. It provides 18 aircraft loading positions along two fingers connected by tunnel to the terminal.

Sealed construction is provided by the plan. Besides the main terminal building, the proposed layout includes an airport service building, cargo warehouse, airmail building, etc., and a hydrant refuelling system.

The design anticipates expansion beyond the forecast requirements for 1980, it is reported. B.C. Research Council supplied forecast data. Phillips Barratt and Partners, Vancouver, were the prime consulting engineers on design and cost estimate of the terminal facilities. Collaborating architects were Thomson, Berwick & Pratt.

Equipment for Dominion Foundries and Steel new 3-stand continuous hot-mill at Hamilton, Ont. The 12,000-kw. d-c set consists of three 4000-kw. generators and one 15,000-hp. synchronous motor.



JOINT REPORT of the COMMITTEES on CONFEDERATION

as appointed by the Canadian Council of Professional Engineers and The Engineering Institute of Canada

The President and Council,
Canadian Council of Professional Engineers.

and

The President and Council,
The Engineering Institute of Canada.

March 18th, 1959

Gentlemen:

Herewith for your consideration is the report of the Committees on Confederation—each as appointed by the Canadian Council of Professional Engineers and the Engineering Institute of Canada. This is a *joint* report.

The report is submitted in five parts—designated as Parts "A", "B", "C", "D", and "E".

The report has been approved by the Committees—each of which was appointed by your councils. Committee and sub-committee meetings have been conducted on a *joint* basis throughout

By way of explanation, comments in regard to the report are as follows:—

PART "A"—re-affirms the eight basic clauses of confederation as originally stated. These were approved in broad principle at the 1958 annual meetings of the respective councils. The only change in this part is found in Clause 8—where the assessment is raised to $6.25 from $6.00.

PART "B"—deals with the development of a budget considered to be adequate for the first or early years of operation of a new National Body.

PART "C"—this portion of the report deals with interpretation and/or explanation of intent—as interpreted by members of the joint committee and may be used for amplification of Clauses 1 to 8. It is anticipated that these explanations will be of assistance in understanding by those less familiar with the problems of Confederation.

PART "D"—this part deals with procedures for presentation and implementation of the recommendations of the report to the constituent members of Canadian Council of Professional Engineers.

PART "E"—this part deals with the requirement of presentation and implementation to the Council and members of the Engineering Institute of Canada.

With the presentation of this report, it is the belief of your committees that their terms of reference have been completed. However, if it should be the decision of your Councils to proceed further, your committees are prepared to assist in any way as they may be requested, to further the recommendations of this report.

Respectfully submitted on behalf of
CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS
Committee on Confederation.

JOHN H. FOX, P. Eng., M.E.I.C.
Chairman

Respectfully submitted on behalf of
THE ENGINEERING INSTITUTE OF CANADA
Committee on Confederation.

IRVING R. TAIT, P.Eng., M.E.I.C.
Chairman

PART A

CLAUSE 1.

It is recommended that a new National Body combining the Engineering Institute of Canada, and the Canadian Council of the Associations and Corporation of Professional Engineers, be formed. The combination of these organizations will enable enlarged services to be rendered to the professional engineers of Canada.

CLAUSE 2.

Full Membership in the National Body shall be confined to members of the provincial and territorial associations and Corporation of Professional Engineers. There shall be no other way that full Membership may be obtained. There will be other grades of non-voting membership, such as Honorary, Fellow, Student, etc., as approved by the National Body.

CLAUSE 3.

The Council of the National Body shall be composed as follows: a president, and two vice-presidents (East and West) elected, the immediate past president, and representatives of the provincial and National bodies as follows: one representative appointed by the council of each of the provincial bodies, and additional representatives elected according to the membership of the provincial bodies; provinces with 301 to 5,000 members shall elect one additional representative; those with 5,001 to 10,000 members shall elect two additional representatives; and those with over 10,000 members shall elect three additional representatives. The elected representatives shall not be members of their provincial councils and shall be voted on by the full membership of their province. Such elections shall be conducted by the provincial bodies.

The first council of the National Body shall therefore be composed as follows:

President and two vice-presidents (East and West) elected.

Alberta	– 2 members	1 appointed by Council of provincial body and 1 elected at large—not serving on provincial council.
British Columbia	– " "	
Manitoba	– " "	
New Brunswick	– " "	
Nova Scotia	– " "	
Saskatchewan	– " "	

Newfoundland	– 1 member (appointed)
Prince Edward Island	– " "
Yukon	– " "

Quebec	– 3 members	–1 appointed by Council of provincial body and 2 elected at large—not serving on provincial council.
Ontario	– 4 members	–1 appointed by Council of provincial body and 3 elected at large—not serving on provincial council.

NOTE: The officers and representatives to be elected to the first council from the membership, shall be members of the present Engineering Institute of Canada, as well as members of their respective provincial bodies.

CLAUSE 4.

No decision by the council of the National Body shall be binding upon the members of the provincial bodies if such decisions in any manner concern the application of the provincial engineering acts or other provincial acts. They shall be binding in all other cases.

CLAUSE 5.

Branches will be established by the National Body at the request of a group of individuals of a community after such request has been processed and approved by the council of the appropriate Provincial Body. The branch charter and by-laws shall be approved and issued by the National Body after receipt of recommendation from the Provincial Body concerned. This will assure uniformity in the formation and operation of branches throughout the country. The branches will manage themselves in accordance with their approved charter and by-laws and will receive services both from their Provincial Body and the National Body.

CLAUSE 6.

It is recommended that a national journal be published.

CLAUSE 7.

Decision on the location of Headquarters of the National Body should not be a prerequisite to Confederation. Such decisions should be made the responsibility of the early councils.

CLAUSE 8.

The annual assessment shall be $6.25 per member.

PART B

Details of budget needs of a proposed new national engineering body to be formed by the confederation of THE ENGINEERING INSTITUTE OF CANADA and the CANADIAN COUNCIL OF THE ASSOCIATIONS AND CORPORATION OF PROFESSIONAL ENGINEERS.

1. STATEMENT OF AUTHORIZATION

The joint committees on confederation appointed a sub-committee to study the preparation of an operating budget for the proposed National Body and the amount of the assessment per member. This report has been prepared after a thorough study of the matter including an examination of the operations and the financial statements of the existing National Body.

2. BASIC DATA

(a) The proposed organization and budget is based on the present professional membership of approximately 32,000 members.

(b) The staff requirements are based upon continuing with one National Body the major services now provided by the Canadian Council of Professional Engineers and The Engineering Institute of Canada without duplication or overlapping of such operations and services.

(c) The organization and estimated budget are considered applicable only to the first or early years of operation. Enlarged services and programmes can be anticipated as the national organization develops, also an enlarged membership is certain so that the estimates herein may be considered as basic only.

(d) A simple organization chart is appended to this report —indicating what are considered to be basic or minimum staff requirements for the National Body.

(e) Fee accounting and collection will be handled by the offices of the Provincial Bodies;—(where the provincial membership does not warrant the support of an office staff these services will be rendered by the office of the National Body with the cost charged to the province concerned).

(f) Funds have not been provided in these estimates for the operation of a national journal. It is proposed that the Journal shall be operated as a separate entity and will be self-supporting.

PART B

3. BUDGET NEEDS

Building Accommodation:

(Based on an owned building)		
Operating expenses per year		12,000.00
Office expenses		
(a) Salaries —		
General Administration	26,000.00	
Divisional Administration	43,000.00	
Accounting, etc.	9,000.00	
Programmes, etc.	19,400.00	97,400.00
(b) Expenses — (Gen. & Admin.)		
Telegrams & Postage	5,000.00	
Telephones	2,500.00	
Supplies	9,000.00	
Audit	1,000.00	
Misc.	5,000.00	22,500.00

General Programmes

2 Council Meetings and 1 Annual Meeting	10,000.00	
3 Executive Committee Meetings	5,000.00	
Annual Meeting (deficit)	3,000.00	
Staff Travel	5,000.00	
Student Prizes	600.00	
Library—including salaries	13,000.00	
Conferences and Committees with other societies	5,000.00	
Pensions (staff)	5,000.00	
Conferences on Education	5,500.00	
Student activities	3,000.00	
President's Travel	4,000.00	
Sundry	1,500.00	60,600.00
CONTINGENCIES	5,000.00	5,000.00
TOTAL BUDGET		$197,500.00

Total Assessment per member—approx. $6.25 per year

SECRETARY GENERAL

- Executive Secretary (1)
- Stenographer (1)

ADMINISTRATION

Exec. Assts.	3
Stenographers	3
Tel. Operator	1
Gen. Clerical	1

ACCOUNTING & RECORDS

Accountant	1
Records Clk.	1

MEETINGS—TECHNICAL PROGRAMMES

Tech. Prog. Director	1
Stenographer	1
Employment Opport.	2

FUTURE

Engineering Assts.	2
Stenographers	2

JOURNAL PUBLICATION

Under this section all professional activities and the relations with other societies and professions will be administered.

Under this section activities will be carried out which relate to that of a technical professional society.

NOTE: *While not specifically indicated on the chart, monetary provision is made in the foregoing budget for librarians and building maintenance services as are now provided in the existing E.I.C. Headquarters.*

CONFEDERATION REPORT

PART C

CLAUSE 1.

The joint committee recommends that:

I. the charter of the Engineering Institute of Canada originally issued in 1887 be the basic charter for the New National Body. The constitution, by-laws, and objectives to be revised to meet the terms of the clauses of the agreement between The Engineering Institute of Canada and the Canadian Council of the Associations and Corporation of Professional Engineers.

II. the agreement for Confederation be drawn up between The Engineering Institute of Canada and the Canadian Council of Professional Engineers; each association and corporation to sign the final legal documents as constituent members of the Canadian Council.

III. the choice of name for the new body be left to the provisional council of the National Body.

The Provincial Bodies shall have complete jurisdiction over the administration of the Professional Engineers' Act within the province, which among other things embraces registration and enforcement of the regulations, protection of the public, and the maintenance of high standards.

The National Body shall have jurisdiction over matters relating to the dissemination of knowledge useful to the profession, which among other things shall include the holding of technical meetings and the publication of professional literature, assistance in matters related to education, public recognition of the profession at all levels both at home and abroad.

The National Body shall represent the profession in national and international matters when such representation is desirable, it being recognized at all times that the opinions and wishes of the Provincial Bodies shall be of prime importance in forming policy for such representation.

It is proposed that the new National Body will render enlarged services to its member engineers, through the carrying-out of the following aims and objectives:

(a) to develop and maintain high standards in the engineering profession.

(b) to facilitate the acquirement and the interchange of professional knowledge among its members.

(c) to advance the professional, the social and the economic welfare of its members.

(d) to assist in the development of uniform registration qualifications and examination schedules.

(e) to act in an advisory capacity in connection with legislative matters common to all of the professional provincial bodies.

(f) to enhance the usefulness of the profession to the public.

(g) to collaborate with the universities and other educational institutions in the advancement of engineering education.

(h) to promote intercourse between engineers and members of allied professions.

(i) to co-operate with other societies for the advancement of mutual or national interests.

(j) to encourage original research, and the study, development and conservation of the resources of Canada.

(k) to provide a forum for the discussion of problems common to all engineering bodies.

(l) to provide for the publication of a national Journal and technical and professional papers and transactions.

(m) to act as a recognized national voice speaking on behalf of all the professional engineers of our country.

PART C

CLAUSE 2.

The significant word in this clause is "full" before the word "membership". In essence this means that to be a Member (with a capital "M") of the National Body one must be a registered engineer.

Persons who are corporate members of the Institute on the effective date of the agreement, if not then registered engineers, will have a limited period (suggest five years) for the privilege of becoming full Members. Every effort should be made to get such corporate members to register and become full Members.

It is recognized that in some instances registration may not be a legal requirement, particularly for persons who have retired from engineering, and in others where a non-Canadian is concerned it may not be possible to obtain registration. Such persons need not be registered but their membership in the National Body would be distinguished from full Membership by a different membership classification.

Special provisions and classifications will be made for other members of the National Body such as Honorary, Life, Retired, non-resident in Canada, Students, etc. Further consideration should be given to the voting rights of such members.

CLAUSE 3.

(a) "Representatives elected according to the membership of the provincial bodies". This is interpreted to mean that representatives shall be elected by the members of the National Body within a province or territory.

(b) "Full membership of their province", is interpreted to mean the members of the National Body within the province.

(c) "Such elections shall be conducted by the provincial bodies". This phrase applies to the first election or appointment—subsequent elections would be held by the National Body.

(d) Clause 3 effects a democratic compromise for the election of the National council. It is designed to prevent the council from being unduly swayed by an overbalancing representation from any one province.

CLAUSE 4.

This clause is inserted to avoid any legal infringement by the National Body on any provincial legislation.

CLAUSE 5.

This clause provides for the establishment of local branches of the engineering profession in communities where required. It is understood that existing branches will continue their existence under the new organization without going through prescribed formalities.

It is recommended that every effort be made to merge or join together branches in any community where a branch of each organization exists at the time of confederation.

No specific provision is made in the joint annual fee for financing the branches. It is recognized that some such provision is necessary. It is suggested that the provincial bodies, when rendering the annual joint account for fees should include an item to cover branch membership.

CLAUSE 6.

It is understood that the National Body would publish a national engineering journal and in addition be responsible for the publication of transactions, and such technical papers as authorized by the Council.

CLAUSE 7.

In order to facilitate the organization and initial operation of the new National Body, the committee recommends that the staff of the organization be housed in the existing Engineering Institute of Canada building, on Mansfield St., in the City of Montreal.

CLAUSE 8.

This assessment will be made on the total membership of each provincial or territorial body, and is in addition to the provincial registration fee. This figure has been developed on the basis of the present number of registered engineers, i.e. 32,000. It should be noted that it does not include any provision for financial assistance to the branches.

This assessment will include a subscription to the national journal. (The present subscription to the Engineering Journal is $4.00 per year).

CONFEDERATION REPORT

PART D

**Implementation of the recommendations of the report of the committee on confederation to—
CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS**

SUGGESTED PROCEDURES

1. That this report be reviewed and accepted by the Executive and council of the Canadian Council of Professional Engineers.

2. That this report be forwarded to the constituent Councils of the Provinces—for acceptance. It is recognized that procedures in all provinces are not the same, i.e. Provincial Councils may act for some associations while others may require reference to their membership.

3. That the Provincial Councils be requested to give enabling authority, to the next Canadian Council of Professional Engineers to proceed with the implementation of the terms of this report.

4. That such enabling authority, (para. 3.), be secured for the early appointment and establishment of a national provisional council to be known as "The Engineers Confederation Commission".

The duties of the "Commission" to be as follows:

(a) to draw up a constitution, by-laws, and legal details for the confederation of the Engineering Institute of Canada and the Canadian Council of the Associations and Corporation of Professional Engineers in conformity with the eight basic clauses laid down by the joint committee. Part "C" of this report is included as a guide to the Commission.

(b) The Commission will be bound by the terms of Clauses 1 to 8 of Part "A" of this report.

(c) The membership of the Commission to consist of a chairman and a vice-chairman, to be appointed jointly by the councils of the Engineering Institute of Canada and the Canadian Council of Professional Engineers.

(d) It is also recommended that the members of the commission be determined as follows:

Newfoundland, Prince Edward Island, Yukon Territories

One member from each of these areas to be appointed jointly by the provincial association council, and the Engineering Institute councillors of the **branches within the province.**

Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta, and British Columbia

One member to be appointed by the Council of the Association within the province designated. One member from each province to be appointed by the Councillors of the branches of The Engineering Institute of Canada in the province.

Quebec

Two members to be appointed by the Council of the Corporation. Two members to be appointed by the Councillors of the branches of the Engineering Institute of Canada in the province.

Ontario

Two members to be appointed by the Council of the Association. Two members to be appointed by the Councillors of the branches of the Engineering Institute in the province.

It will be noted that for the purposes of the Commission, the members are to be appointed rather than elected, and that only one Vice-Chairman is appointed.

The Commission is to be appointed for a term of one year —subject to extension or re-appointment for a further term, not to exceed one year.

Upon the installation of the first council, regularly constituted, the "Commission" shall be dismissed.

The first regularly constituted council is to be elected and appointed in accord with Clause 3—Part "A"—of this report.

Under this arrangement the "Note" at the end of Clause 3 —page 2—Part "A", becomes redundant and unnecessary and should be disregarded.

CONFEDERATION REPORT

PART E

Implementation of the recommendations of the report of the committee on confederation for the council of—
THE ENGINEERING INSTITUTE OF CANADA.

SUGGESTED PROCEDURES

1. That this report be reviewed and accepted by the Council of The Engineering Institute of Canada.

2. That after approval by the Council the report be submitted to all corporate members of the Institute with the ballot which was approved by the Council at its meeting in Toronto on January 31st, 1959, and accompanied by an appropriate covering letter from the president.

3. On receipt of a favourable ballot, Council appoint its representatives to the Engineers Confederation Commission.

The duties of the Commission to be as follows:

(a) To draw up a constitution, by-laws and legal details for the confederation of the Engineering Institute of Canada and the Canadian Council of the Associations and Corporation of Professional Engineers in conformity with the eight basic clauses laid down by the joint committee. Part "C" of this report is included as a guide to the Commission.

(b) The Commission will be bound by the terms of Clauses 1 to 8 of Part "A" of this report.

(c) The membership of the Commission to consist of a chairman and a vice-chairman, to be appointed jointly by the Councils of The Engineering Institute of Canada and the Canadian Council of Professional Engineers.

(d) It is also recommended that the members of the Commission be determined as follows:

Newfoundland, Prince Edward Island, Yukon Territories

One member from each of these areas to be appointed jointly by the provincial association council, and the Engineering Institute councillors of the branches within the province.

Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta and British Columbia

One member to be appointed by the Council of the Association within the province designated. One member from each province to be appointed by the Councillors of the branches of the Engineering Institute of Canada in the province.

Quebec

Two members to be appointed by the Council of the Corporation. Two members to be appointed by the Councillors of the branches of the Engineering Institute of Canada in the province.

Ontario

Two members to be appointed by the Council of the Association. Two members to be appointed by the Councillors of the branches of The Engineering Institute of Canada in the province.

It will be noted that for the purposes of the Commission, the members are to be appointed rather than elected and that only one vice-chairman is appointed. The Commission is to be appointed for a term of one year, subject to extension or re-appointment for a further term, not to exceed one year. Upon the Installation of the first council regularly constituted, the Commission shall be dismissed.

The first regularly constituted council is to be elected and appointed in accord with Clause 3—part "A"—of this report.

Under this arrangement the "Note" at the end of Clause 3 —page 2—Part "A", becomes redundant and unnecessary and should be disregarded.

Month to Month

News of the Institute and the Profession

COMMENT
CORRESPONDENCE
ELECTIONS
AND TRANSFERS

Regional Conference, Sudbury

The first Northern Ontario Regional Conference, held in Sudbury, on April 25, gave the engineers of this region the welcome opportunity of meeting to hear discussions on the engineering future of Canada in the next twenty years.

With all the Northern Ontario branches participating, and with an invitation extended to all engineers and their ladies, the attendance of 150 was gratifying to the very active committee making arrangements for this first-of-its-kind conference in this region.

Consideration of Canada's future is obviously of interest to engineers, and it proved to be so as the technical meeting proceeded. Three speakers dealt with three different parts of the general picture:

Energy: Nuclear, Hydro-Electric, Carbonaceous, Solar, J. L. Olsen, Canadian General Electric Co., Kingston, Ont.

Transportation: Land, Air, Water, A. Lightbody, Assistant Manager of Research, and A. L. Bingham, Canadian Pacific Railways.

Defence, Maj. Gen. W. S. Macklin.

Mr. Olsen said that Canada's future lies in atomic power. The full capacity of carbonaceous fuels has almost been realized. Electric power has been utilized almost to capacity in the highly industrialized areas in Southern Ontario and Quebec. Solar energy is not sufficient in the northern latitudes. The only workable solution, in Mr. Olsen's opinion is production of energy by fission, atomic power. Every aspect is in Canada's favour, he said.

General Macklin had some critical comment to make on Canada's defence system. This was another thought provoking session dealing with the controversial defence decisions of the past five years and the necessary ones in the next twenty years.

Dr. Garnet T. Page, general secretary of the Engineering Institute, spoke at the evening banquet on the subject of Travelling in South America.

On the lighter side, there were many opportunities for the delegates to meet — at a luncheon, at the reception and cocktail party, and at the conference banquet. Climaxing the day there was the informal conference dance. The ladies accompanying the delegates enjoyed themselves immensely, with a program arranged by Mrs. F. A. Orange.

Credit for the success of the meeting is difficult to distribute. The support of so many members for this important project rewarded the efforts of the committee.

W. B. Ibbotson is the Branch chairman at Sudbury. R. P. Crawford was the conference chairman. Other members in charge of conference services were: W. J. Ripley, Jr., registration, T. C. Robertson, program, F. deStefano, welcome, R. H. Moore, speakers and special guests, P. R. McAdam, accommodation, F. Jackson, publicity. Representatives of the other E.I.C. branches on the committee were: W. A. Hogg, Sault Ste. Marie, and T. C. McNabb, North Bay. Notable for their assistance were P. F. Adams, C. A. MacMillan, F. G. Burchell, G. Charlap, and E. T. Querney.

Participating in the Sudbury Meeting: A. L. Bingham (left), A. Lightbody, J. L. Olsen, Maj. Gen. W. S. Macklin, and W. B. Ibbotson, branch chairman.

Dr. Garnet T. Page (left), a guest speaker, with Ralph Waddington of International Nickel, and F. A. Orange, E.I.C. councillor.

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 in April 1959.

Member: H. Z. N. Argun, Toronto; E. Bernhardt, Montreal; E. L. Bowerman, Toronto; J. H. Dyer, Bell Island, Nfld.; J. K. Erskine, Montreal; H. L. Ferguson, Montreal; G. Fournier, Rimouski; E. C. Hale, Sturgeon Falls; J. W. Inglis, Vancouver; E. J. Johnson, Preston; W. Kalbfleisch, Ottawa; L. R. Kidman, London, Eng.; G. Koopmans, London, Ont.; D. I. MacMurchy, Toronto; I. Mansell, Montreal; F. W. Patterson, Niagara Falls; M. Reinbergs, Hamilton; M. Van Wijk, Arvida; C. S. Wiffen, Toronto.

Junior: R. J. Blake, Toronto; A. A. Boscariol, Windsor; V. P. Despatis, Montreal; R. D. Detwiler, Halifax; D. J. Dresselhuizen, Montreal; P. A. Hanley, Montreal; L. L. Hartford, North Bay; I. G. Holmes, Toronto; J. F. Schultz, Shawinigan; J. G. Spence, Kingston, Ont.

Affiliate: A. M. Hurley, Calgary.

Junior to Member: H. T. Floyd, Belleville; H. L. Isabelle, Montreal; D. C. Johnston, Ottawa; G. R. Leonard, Montreal; J. S. F. Ma, Toronto; M. Mindess, Toronto; D. W. Prendergast, Montreal; M. D. Robb, Edson, Alta.; D. H. Shields, Downsview; S. W. Shishakly, Montreal; R. R. Smith, Vancouver; J. A. Stewart, Hull; R. A. Williams, Victoria.

Student to Member: C. J. Macfarlane, Chalk River.

STUDENTS ADMITTED

University of Toronto: W. A. Adams, L. W. Argue, B. L. Barrett, D. R. Bonis, A. G. Carless, D. S. Davis, P. R. Ferris, G. A. Harris, W. Katarynczuk, R. G. Kraemer, P. G. S. Large, J. S. McGavin, G. L. A. Palinkas, A. Salumets, G. I. Tebbutt, J. D. Wilcox, C. C. Wilson, S. Yanchula.

St. Francis Xavier University: E. L. F. Anthony, R. G. Butler, F. Cianfaglione, W. J. Donovan, F. G. Doyle, J. H. George, P. I. Hurley, J. C. Joannette, W. V. Kukulki, M. A. Lafreniere, E. J. Poirier, P. E. Smith.

Acadia University: M. R. Bacon, R. M. Chown, D. E. Cushing, C. G. Hatfield, H. B. Hatt, M. Hon, A. R. McLaughlin, J. H. Oyler, J. I. Paul, C. W. Ploeg, K. C. Woo, C. E. Zwicker.

University of British Columbia: E. I. Dickson, R. E. Elcox, D. O. Haaheim, D. K. Holzman, G. E. Massey, M. A. Merlo.

University of New Brunswick: J. D. Ellison, W. J. Evans, D. M. Goss.

University of Alberta: B. A. Ellis, A. D. Turnbull.

McMaster University: H. J. Cox, F. A. Holik.

University of Western Ontario: S. G. Kennedy, F. J. Myslik, J. D. Ort.

Queen's University: L. S. Norman.

University of Sherbrooke: J. G. Bergeron.

Sir Geo. Williams College: P. Hawryluk.

University of Illinois: D. M. Shah.

University of Toronto: R. W. Millen.

A.P.E.B.C.: A. Canning.

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: P. F. Proctor.

SASKATCHEWAN

Members: N. R. Dunne, W. J. Harper, T. C. Morgan, O. J. E. Wilson; **Junior:** D. M. Kent; **Junior to Member:** R. L. Frederick, J. W. Lukey, J. R. Mutch, J. H. Tims; **Student to Junior:** R. H. Billings, D. G. Bishop, A. D. Carlson, H. R. Daniel, H. G. Gilchrist, W. F. Maguire, E.C. Sherwin, J. J. Syrnyk; **Students:** J. A. Colgan, M. D. Glazier, E. D. Lidfors.

NOVA SCOTIA

Members: C. C. R. Bell, J. F. Lindsay, C. F. MacNeil; **Junior to Member:** H. W. Doane, R. N. Robertson, R. P. Whalen, K. D. Tuddenham.

MANITOBA

Member: S. C. Roberts.

Railway Engineering

The Institution of Civil Engineers, London, England, is now publishing monthly a publication entitled "Railway Engineering Abstracts". The civil, mechanical and electrical aspects of railway and other engineering are covered. The ordinary rate of subscription is £2. a year for 12 issues post free. Cost of single copies is 4s. 0d., post free.

Advertising the Engineer

Our April issue announced the first winners of certificates which The Engineering Institute of Canada now offers monthly for the best advertisement in *The Engineering Journal.* We confidently leave it to the independent judges to decide on the relative merits of advertisements directed to engineers in their own Journal. Meanwhile advertising addressed to other readerships is of prime importance to engineers when it has the opportunity to reflect their status in the community. That a well-conceived advertisement can serve our profession in this way has been admirably demonstrated by a number of prominent advertisers including General Electric, General Motors and Honeywell Controls. Among the advertisements that have recently been appearing in various Canadian publications the Honeywell Controls series, "Look to the Engineer", is especially commended. It is hoped that this trend in advertising will be encouraged by all who seek adequate recognition for the engineer's part in Canadian development.

The Canadian Conference on Education Issues a General Report and Program

THE 850 DELEGATES who attended the national conference on education held in Ottawa in February 1958 resolved that the conference organization should be maintained to work for the objectives outlined at that time. During its first year this organization has been chiefly occupied with determining the degree of public support for a widespread, completely voluntary effort; with a suitable organization structure; and finally with aims and objectives and a program.

The C.C.E. was created to bring laymen and educators together for an exchange of information and ideas at a time of crisis in education. Its purpose is to stimulate constructive public support for education in Canada.

Conference Widely Supported

Representatives of both French and English language groups—organized labour, business and industry, education, agriculture, women's associations and many other segments of society—direct the work of the Conference. The sponsors are 51 national organizations, representing some five million people. Canadian business and industry has contributed some $40,000 in the past year at the invitation of a finance committee headed by Mr. W. E. Williams, president of Procter and Gamble Company of Canada Limited. Daily and weekly newspapers, magazines, the C.B.C., private radio and television stations, the National Film Board, and those in the field of advertising have given assistance. As a result of a major advertising campaign 50,000 copies of the booklet "Crossroads" have been distributed during the year.

Aims

The Conference recognizes that responsibility for education lies at the provincial and community levels, and its general report and program, issued in March, indicates that most C.C.E. activity will take place at these levels. The program will be reviewed annually to ensure that the work reflects the changing needs of the nation and to endeavour to measure Canada's educational progress against those needs. This program is based on the following beliefs:

1. That constructive public debate and wide dissemination of information about education will contribute materially to the pub-

lic support necessary to the solution of the problems facing Canada's educators.

2. That everyone should have the opportunity to obtain the education he wants and needs within the limits of personal aptitude and ability.
3. That an essential responsibility of the citizen is to demand highly capable people to carry on the work of education and educational administration, and to provide them with proper buildings and facilities, so that they may use their professional training and ability to the best advantage of the community.
4. That Canadians, conscious of the vastness of their country, should work toward the elimination of the penalty which geography often places on education opportunity of those who live in rural and remote areas.

Trained Teachers

The Conference will therefore work to ensure that all teachers receive adequate training and prestige in the community, with commensurate salary levels and financial assistance for those in basic or advanced training. It will also seek improved conditions for rural teachers.

Adequate Buildings and Equipment

Efforts will be made to co-ordinate school site planning with other municipal planning, and to bring the student's technical equipment into line with that which he will use in earning his living.

Improved facilities will be sought for rural schools, and the advantages of wider use of educational television explored.

A Fuller Education

The Conference will also work for the introduction of English or French as a second language in elementary grades at as early an age as possible and for continued education to be made available to all who have the desire and capacity for it. It will seek the assurance that outstanding pupils in primary and secondary schools are encouraged to proceed to universities or professional schools.

More Money for Education

Other objectives in the program are the spending of a larger proportion of our national income on education, the provision of more scholarships, loans and bursaries and the expansion of research into all levels of education.

THE ENGINEERING INSTITUTE OF CANADA

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A. H. Douglas, Saskatoon, Sask.
P. F. Fairfull, Victoria, B.C.
A. L. Furanna, London, Ont.
H. A. Gadd, Cobourg, Ont.
E. D. Gray-Donald, Montreal, Que.
N. Gritzuk, Whitehorse, Y.T.
H. N. Hatfield, Penticton, B.C.
T. C. Higginson, Saint John, N.B.
A. D. Janitsch, Belleville, Ont.
Viggo Jepsen, Grand'Mere, Que.
D. B. McKillop, Fort William, Ont.
J. R. Menard, Rimouski, Que
J. W. Millar, North Bay, Ont.

Until May, 1960

E. T. W. Bailey, Hamilton, Ont.
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J. H. Budden, Montreal, Que.
P. E. Buss, Thorold, Ont.
M. R. Campbell, Sydney, N.S.
E. L. Cavana, Orillia, Ont.
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H. E. Meadd, Cornwall, Ont.
R. S. Morrow, New Glasgow, N.S.
P. F. Peele, Peterborough, Ont.
W. B. Pennock, Ottawa, Ont.
L. J. R. Sanders, Galt, Ont.
T. D. Stanley, Calgary, Alta.
G. F. Vail, Halifax, N.S.
M. P. Whelen, Toronto, Ont.
A. McD. Wilson, Sault Ste. Marie, Ont.
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A.C.M. Davy, 1277 West 33rd Ave., Vancouver 13

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations.

ALBERTA

Annual Meeting

The Association of Professional Engineers of Alberta held their 1959 annual meeting April 3-4 at the Palliser Hotel in Calgary.

Elected as officers at the time were C. A. Stollery, president; D. C. Jones, vice-president; Dr. G. W. Govier, past-president; councillors elected were Dr. R. N. McManus, W. D. Stothert, J. C. Scott, R. D. Hall, N. J. Allison, Dr. George Ford, W. A. Smith, B. F. Willson, P. M. Butler, F. A. Kidd, Dr. J. Spivak, W. D. Suitor, J. G. Dale, K. W. Mitchell, and L. A. Thorssen.

I. G. Finlay was elected registrar and J. F. McDougall, deputy registrar.

Dr. Gerald W. Johnson, guest speaker at the meeting, declared the feasibility of thermo and nuclear explosions for use in peacetime industry. He dispelled the fear of radioactive fallout surrounding such nuclear explosions through charts, slides and films of recent tests conducted at the Nevada proving grounds, where radio activity is captured and held underground or dissipated through the use of minerals.

Two projects Dr. Johnson hopes to see the Canadian government allow to go ahead are the production of a low viscosity oil from the Athabasca tar sands and the clearing of a channel harbour to be blasted out of solid rock near Cape Thompson in Alaska.

Two $200 bursary awards were presented by President Dr. G. W. Govier to University of Alberta students H. W. Webb and J. A. Allen for having achieved highest standing in their first year of engineering.

ONTARIO

C. T. Carson Addresses Meeting

If Canadian-made goods are to compete successfully in world markets with those produced in Europe and Asia, we must continue to increase productivity and at the same time, maintain high standards of quality, some 400 professional engineers were told recently.

Addressing a special regional meeting of engineers, C. T. Carson, P.Eng., of Windsor, Ont., past president of the Association of Professional Engineers of Ontario, said the professional engineer had an important role to play in meeting this challenge.

"In large degree, responsibility for production standards, efficiency, quality control and unit cost must be assumed by engineers," he told his audience. He added that new machinery, automated procedures, product design, plant layout and other developments which would contribute to increased efficiency lay in the engineer's domain.

"Unfortunately, we are not blessed with the density of population to provide a domestic-market profit cushion, and to reduce unit costs as are our industrial neighbours and competitors to the south," he stated.

"Also, we don't have skilled tradesmen willing to work at one-third the Canadian wage scale such as some of our competitors in Europe, not to mention one-tenth the Canadian wage scale paid to workers by the Japanese industrialist."

Mr. Carson warned that in the years ahead, Canada must overhaul its economy. He noted that in 1958, the Canadian standard of living declined for the first time in recent years.

"While wages were going up 1.8 per cent, prices increased 2.6 per cent. Gross National Product set an all-time record, but in the midst of the productive glow, half a million people were unemployed," he declared.

Mr. Carson said the manufactured goods increment must continue to gain "if we are to have any measure of full employment and general prosperity".

Referring to engineering universities, he said there was a growing need for quality rather than quantity in graduating classes, and noted that in recent years, the number of schools teaching engineering had increased to nine.

He called for elimination of "engineering wastage" where professional engineers are employed in sub-professional jobs. And he pointed out that the increased emphasis on productivity would help in solving the problem.

Secretary Treasurer Appointed

David L. Turner, of Toronto, has been appointed secretary-treasurer of the Association of Professional Engineers of Ontario.

Mr. Turner, a native of Vancouver, was formerly with Avro Aircraft Co. where he was employed as a senior stress engineer. A graduate in aeronautical engineering from the University of Toronto, he served in World War II as a pilot in the RAF Coastal Command.

Mr. Turner brings to his new position, five years of APEO committee work, having served on the company groups committee and the engineering technicians program. He served on the latter's certification board since its inception by the Association three years ago.

Certification of Technicians

The certification program for engineering technicians and technologists originated by the Association of Professional Engineers of Ontario in June, 1957, is now being adopted by the United States, it was announced recently by T. M. Medland, executive director of the A.P.E.O.

The National Society of Professional Engineers in Washington, D.C., has recommended to all of the state societies that they adopt the Ontario program. The only revision in the program would be made to fit U.S. standards of education.

Already the Wisconsin Society of Professional Engineers has announced it was immediately adopting the program. It is expected that other state societies will follow.

The A.P.E.O. was the first engineering body to set up a plan whereby engineering technicians are graded according to their training and experience into four categories. There are three grades of technicians and one of technologists.

The certification program was based upon the belief that it would encourage technicians to progress through the four grades to top proficiency, and would also serve as a means of defining the upgrading of technical employees.

"Technicians and technologists play a valuable role in engineering by assuming many of the non-professional duties of an engineer, thus permitting the latter to concentrate on full-time professional work," says Dr. Geo. B. Langford, P.Eng., Toronto chairman of the certification board.

At present there are between 900 and 1,000 certified engineering technicians and technologists in Ontario with certification being carried out at the rate of 75 new members per month.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

W. R. Stickney, M.E.I.C. died on March 4, 1959 at Toronto.

Born on December 1, 1911 in Elora, Ontario, he graduated from the University of Toronto in 1936 with a B.A.Sc. degree in chemistry later serving with Canadian Bridge Co. Ltd., Walkerville and Canadian Vickers Ltd., Montreal. For the past 12 years he had been chief welding engineer of the Canadian Welding Bureau.

N. J. A. Vermette, M.E.I.C. died on April 24, 1959.

Mr. Vermette was educated in Montreal where he attended the College Ste Marie and the Ecole Polytechnique.

From 1922 until 1927 he worked with the technical services department of the City of Montreal.

In 1927 he was named manager of the City of Shawinigan and in 1939 until his death was a civil engineer in charge of the provincial roads department survey division for Western Quebec.

He was active in youth organizations and from 1955 until this year was president of Verdun School Commission.

Thomas Maxwell Fyshe, civil engineer in mining promotions, died recently at his home in Toronto.

Born in Halifax, he received his education in Germany and McGill University where he graduated in science in 1905.

In 1940 he came to Toronto and was with the Nesbitt and Thomson Company Ltd., investment house in Montreal for a number of years. During the Second World War he was assistant to the oil controller for the Wartime Prices and Trades Board. For the past several years he had been with Brewis and White Ltd., Toronto mining securities firm.

He was a director of New Dickenson Mines.

William D. Neeland, M.E.I.C. died in October, 1958.

Born on May 21, 1912 in Moose Jaw, Sask. he graduated from McGill University in 1935 with a degree in geology and chemistry.

In 1929 he joined the Northern Development Company in Fort William, Ont. as chainman.

After working in various mining companies in Canada he joined the Royal Canadian Navy as Lieutenant from 1942 to 1945, returning as geologist with Kennco Explorations Ltd. in Toronto.

Mr. Neeland was consulting geologist and inspector of mines stationed at Flin Flon with the Department of Natural Resources in Saskatchewan and was best known in the mining world for his exploration and outline of the Steep Rock iron ore body.

H. B. Henderson, M.E.I.C. retired president of Cowin & Company Limited died on March 3, 1959.

Mr. Henderson who resided in Winnipeg from 1914 to 1957 was born in New York and graduated in engineering from Cornell University in 1894. He received his master's degree in mechanical engineering from MIT in 1896.

He was well known in the construction industry in western Canada and was a member of the American Society of Civil Engineers.

Arthur Edward McNicoll, M.E.I.C. died on October 11, 1958.

Mr. McNicoll was born in England on August 12, 1892 receiving his education at Royal Masonic School and the Montreal Technical school.

In 1916 he joined the Dominion Bridge Company Limited where was until the time of his death as design & general engineer for the company.

He was well known for the design of steelwork for many buildings in Montreal.

John H. Lapp, M.E.I.C. died on February 20, 1959.

Born on November 28, 1914 in Lincoln, Nebraska he graduated from the University of Nebraska in 1939 with his degree of Bachelor of Arts & Science in geology.

In 1940 he joined the Texas Company, Oklahoma City, Okla. as geologist.

In 1944 until 1954 he worked with various oil corporations in Canada and the United States.

He joined the Stanolind Oil & Gas Co., Regina, Sask. in 1955 where he was consultant geologist.

W. I. Elliott, M.E.I.C. died in December 1958.

Born on November 18, 1898 in Nova Scotia he graduated from Dalhousie University in 1923 with a degree in mechanical and civil engineering following which he joined the Canadian General Electric Company in Lynn Mass.

From 1926 to 1928 he worked with Byrne Mfg. Co. in Cleveland, Ohio and the Grazelli Chemical Company as draftsman.

In 1928 he joined Fraser Brace Engineering Company in Montreal where he was in charge of installing machinery and pipelines at the International Paper Company's plant at Three Rivers and worked on various railway projects until 1938.

Egon Alzner, M.E.I.C. died on February 28, 1959.

Born in Romania on October 21, 1905, he attended technical university in Berlin graduating in 1928 with a degree in mechanical engineering.

From 1929 to 1939 he worked with the Shell Oil Refinery in Romania.

In 1939 he was sent by Shell Oil Refinery on a special training trip to the United States, returning one year later to Romania where he was made technical manager for Shell Oil Refinery at H.Q. Campina.

From 1945 to 1949 he was mechanical engineer with the Military Government, Germany.

From 1950 until the time of his death Mr. Alzner was with Canadian Vickers Ltd., in Montreal where he was named chief estimator for the company in 1955.

Frederick Reginald Sharman, M.E.I.C. died on April 7, 1959.

Born on March 7, 1894 in Swindon, England, he graduated from Swindon & Wilts Technical Institute in mechanical engineering and from 1914 to 1919 served a mechanical engineering apprenticeship with the Great Western Railway.

After serving with the British Expeditionary Force in World War I, he spent the early years of his career working for the various railway projects.

From 1941 to 1946 he worked for the inspection board of U.K. & Canada as deputy inspector of Artillery Carriages and A. A. Mountings later being transferred to the British Admiralty Technical Mission as deputy inspector of Naval Ordinance. At the end of World War II, he was appointed chief district inspector to the contracts settlement board.

From 1946 to 1947 he joined the Waterloo Mfg. Co. handling technical sales of automatic oil fired boilers leaving there to work for the Aluminum Company of Canada as mechanical engineer to Demerara Bauxite Co. in British Guiana for the following two years.

Returning to Canada he was engaged by Canadian Car & Foundry Co. Ltd. in the engineering department from 1949 to 1950.

In 1950 he joined the Canadian International Paper Company as mechanical superintendent, Kipawa Mill.

J. Cecil McDougall, M.E.I.C. died suddenly on April 20, 1959.

Born in Three Rivers, Que. he graduated from McGill University in architecture and engineering and was a representative of McGill on the Montreal City Council.

He was president of the Province of Quebec Association of Architectures in 1926 and a member of Sir George Etienne Cartier Corporation.

At the time of his death he was consultant to the firm of Fleming & Smith, architects, where he had been a partner in the firm for a number of years.

Personals

V. A. M Robertson, M.E.I.C. of Sir William Halcrow & Partners, Consulting Engineers, has retired from the partnership but will remain as a consultant to the firm.

A. G. Asplin, M.E.I.C. (B.Eng. civil., McGill 1938) has been appointed president of Horton Steel Works, Limited, Toronto, Ont.

W. K. Gwyer, M.E.I.C. (B.A.Sc., civil., British Columbia, 1936) has become assistant general manager of the West Kootenay Power and Light Company, Trail, B.C.

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

W. K. Gwyer, M.E.I.C.

R. L. Weldon, M.E.I.C. (B.Sc., M.Sc., mech., McGill, 1917, 1920) has retired as president of Bathurst Power & Paper Company Limited, Montreal. He has been elected chairman of the board to the company.

C. W. West, M.E.I.C. (B.A.Sc., Toronto, 1915) has retired from the post of member of The St. Lawrence Seaway Authority.

Colin B. McMillan, M.E.I.C. (B.Sc., civil, Queen's, 1936) has opened his own office as a consulting engineer in Montreal.

William A. Williamson, M.E.I.C. (B.A.Sc., elec., Toronto, 1934) is an engineer, with N.B. Electric Power Commission, Fredericton, N.B.

R. L. Weldon, M.E.I.C.

F. W. Cranston, M.E.I.C.

Colin B. McMillan, M.E.I.C.

C. Arthur Miller, M.E.I.C.

F. W. Cranston, M.E.I.C. (B.Sc., mech., Queen's 1936) has been appointed vice-president of Industrial Advertising Agency Ltd, Toronto.

A. H. Mingail, M.E.I.C. (B.Eng., elec., Calcutta, 1942) has joined the Canadian Broadcasting Corporation in Toronto as an engineer in the network operations department.

A. E. Beazely, M.E.I.C. of Underwood McLellan and Associates Limited has been transferred from Calgary, Alberta to Saskatoon, Saskatchewan as engineer for the company.

Glenn H. Curtiss, M.E.I.C. (Master's degree in Business Administration, Toronto, civil, 1948, 1950) is now Vice-President of Stone & Webster Canada Limited, Toronto, Ont.

John F. Miles, M.E.I.C. (B.Sc., chem., Queen's, 1948) has been appointed assistant to the general superintendent of the Dominion Iron and Steel division of Dominion Steel and Coal Corporation Limited, Sydney, N.S.

W. Ralph Lewis, M.E.I.C. (B.Sc., B.A.Sc., elec., 1941, 1947) was appointed chief electrical engineer, Dominion Iron and Steel division, of Dosco, Sydney, N.S.

Robert Bezanson, M.E.I.C. (B.Sc., B.Eng., 1948, 1951) has been appointed mechanical and construction superintendent of the Seaboard Power Corporation Limited, Sydney, N.S.

John J. Laffin, M.E.I.C. (B.Eng., elec., Nova Scotia, 1947) has been appointed electrical engineer for coal operations of Dominion Steel & Coal Corporation Limited in Sydney, N.S.

H. C. Maitland, M.E.I.C. has been appointed assistant chief engineer of the Dominion Iron & Steel Division, Dominion Steel & Coal Corporation Limited, Sydney, N.S.

W. G. Ward, M.E.I.C.

Anton A. Goldes, M.E.I.C.

W. G. Ward, M.E.I.C. (B.Eng., elec., McGill 1942) has been appointed general manager, apparatus department, with Canadian General Electric Company Limited, Peterborough, Ont.

Anton A. Goldes, M.E.I.C. (B.Sc., civil, Waterstrand) formerly chief engineer with the Toronto firm of Yolles & Associates announces the establishment of A. A. Goldes & Associates, consulting engineers, Toronto, Ont.

H. Soloninka, M.E.I.C.

J. B. Mantle, M.E.I.C.

C. Arthur Miller, M.E.I.C. (B.A.Sc., mech., Toronto 1936) supervisor of cost studies, scheduling and standards, engineering department of Canadian Industries Limited, has been elected president of the American Association of Cost Engineers, New Hampshire.

H. Soloninka, M.E.I.C. (B.Sc., civil, Queen's 1951) has become manager of Haddin, Davis & Brown (Saskatchewan) Limited, Consulting Engineers.

J. B. Mantle, M.E.I.C., (B.E. mech., Saskatchewan, 1941, M.Sc., mech., Illinois, 1947) professor and head of the Department of Mechanical Engineering at the University of Saskatchewan is the chairman of the Saskatchewan Branch of the Institute.

Paul Riemer, M.E.I.C. (B.Sc., civil, Saskatchewan, 1947) assistant professor of civil engineering at the University of Saskatchewan has been elected chairman of the Saskatoon Section, E.I.C.

J. J. Schaeffer, M.E.I.C. (B.Sc., civil, Saskatchewan, 1946) is chairman for the Moose Jaw Section of the Institute. Mr. Schaeffer is with Underwood, McLellan & Associates, at Moose Jaw.

R. J. Genereux, M.E.I.C. (B.Sc., M.Sc., civil, Saskatchewan, 1951, 1954) planning engineer with the Saskatchewan Department of Highways at Regina, has been elected chairman of the Regina Section, E.I.C.

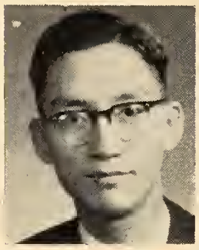
• PERSONALS

Dr. L. Austin Wright, HON. M.E.I.C., was elected president of the Quebec Division of the Canadian Arthritis and Rheumatism Society, of which he has been vice-president for four years. Also Dr. Wright has been reelected president of the Pointe Claire Memorial Library Association.

J. B. Morrow, M.E.I.C. has been working since July 1958 as an engineer for the National Sea Products Limited, Halifax.

William A. Arsenault, M.E.I.C. (B.E. civil, Nova Scotia 1938) is now supervising construction engineer with Quebec Cartier Mining, in supervision of railroad construction.

J. David Boulding, JR.E.I.C. (M.A.Sc., elec., British Columbia, 1959) is with the Electronics Laboratory of the Defence Research Telecommunications Establishment of the Defence Research Board in Ottawa as a Defence Scientific Service Officer.



Chung-Yen Chang, JR.E.I.C.

Ross Salmon, JR.E.I.C.

Chung-Yen Chang, JR.E.I.C. (M.A.Sc., civil, Toronto 1957) is a design engineer with the Hydro-Electric power commission of Ontario, Toronto, Ont.

Ross Salmon, JR.E.I.C. (B.Sc., mech., Queen's 1956) is now research assistant in the department of mechanical engineering at Queen's University, Kingston, Ont.

Stanley W. Young, JR.E.I.C. (civil, McGill, 1956) is located by H. G. Acres Company Limited in Warsak Colony, West Pakistan.

Walter Naumko, JR.E.I.C (B.Sc., civil, M.A.Sc., Manitoba, Toronto 1953, 1958) has been named project engineer, engineering division, with Hunting Technical and Exploration Services Ltd., Toronto.

G. E. Blair, JR.E.I.C. (B.E., mech., Saskatchewan 1957) is now design engineer with Beaver Engineering Co., Toronto, Ont.

Frank Barna, JR.E.I.C. (B.Eng., mech., (power & design) McGill, 1957) is now a power and fuel engineer, utilities division, with Edgar Thomson Works (Braddock) Pittsburgh district, a subsidiary of United States Steel Corp.

M. G. Colvin, JR.E.I.C. (B.A.Sc., civil, Toronto, 1951) chief engineer with the Canadian Kellogg Company Limited has been transferred to the company's Pan American branch in Mexico.

Charles W. Kingston, JR.E.I.C. (B.S.c., elec., New Brunswick, 1956) has been transferred from HMCS Dockyard Esquimalt to HMCS Crescent as electrical officer.

John E. Little, JR.E.I.C. (B.Sc., mech. Queen's 1957) is employed as an engineer (development work in thermodynamics, heat transfer, fluid flow) with the English Electric Company Ltd., Atomic Power Department, Leicester, England.

John A. Fuller, JR.E.I.C.

Austin A. Hills, JR.E.I.C.

John A. Fuller, JR.E.I.C. (B.A.Sc., mech., Toronto 1948) was recently appointed assistant general sales manager for Worthington (Canada) Limited, Toronto.

Austin A. Hills, JR.E.I.C. (B.Sc., physics, Queen's 1949) has been named chief engineer of the Aeronautical Division of Honeywell Controls Limited, Toronto, Ont.

• PERSONALS

Edgar G. Hazle, JR.E.I.C. (B.Sc., mech., Queen's, 1948) is now with Ferranti-Packard Electric Limited, Electronics Division, Toronto, Ont.

E. W. Lucht, JR.E.I.C. (B.Sc., chem. Alberta 1954) formerly a development engineer with the C.I.L. Ltd., at Edmonton is now a process engineer with the company.

Frank John Forbes, JR.E.I.C. (B.A.Sc., mech., Toronto, 1957) is assistant hydraulic engineer with the Ontario Department of Public Works, Toronto.

David G. McKay, JR.E.I.C. (B.Sc., mech., Manitoba, 1949) is a manufacturers agent for Emco Ltd., on Vancouver Island, servicing the commercial and industrial field.

A. A. Williams, JR.E.I.C. (B.Eng., civil, McGill, 1951) is the resident engineer for H. H. L. Pratley on the Canadian approaches of the Ogdensburg-Prescott Bridge, Prescott, Ont.

Howard H. Wyatt, JR.E.I.C. (B.Eng., elec., McGill, 1952) formerly of Montreal, has joined G. M Gest Ltd., Toronto, as manager of the Ontario electrical division.

John D. Brown, JR.E.I.C. (B.Eng., civil, Nova Scotia, 1957) is a student at Imperial College, London, England, under an Athlone Fellowship.

Gerard S. Lemire, JR.E.I.C. (B.A.Sc., civil, Polytechnique, 1951) is a sales promotion engineer with the Aluminum Company of Canada, Montreal.

R. H. Reynolds, JR.E.I.C. (B.Sc., elec., Alberta 1951) of Babcock-Wilcox and Goldie-McCulloch has been transferred from Calgary to Vancouver as manager of the Vancouver Branch.

M. G. Colvin, JR.E.I.C.

S. Lake, JR.E.I.C.

F. I. Morton, JR.E.I.C. (B.Sc., Eng. Phys., Saskatchewan, 1949) is on leave of absence from his position with the Department of Northern Affairs and National Resources, on a Colombo Plan assignment as a hydro development engineer with the Central Electricity Board of Malaya.

Gary N. Hesler, JR.E.I.C. (B.A.Sc., eng. & business administration) field engineer with the Square "D" Company of Canada Ltd., Montreal has been transferred to the Company's Ottawa office.

Eugene Motluk, JR.E.I.C. (B.Sc., mech. New Brunswick, 1957) is an engineer with the Burlington Steel Co. Ltd. in Hamilton, Ontario.

Jean Dupont, JR.E.I.C. (P.Eng., elec., Montreal, 1956) is working for Leblanc & Montpetit, Consulting Engineers, Montreal, Que.

Gordon Dysart, JR.E.I.C. (B.Eng., elec., McGill 1951) formerly of Donnacona, Quebec is now electrical engineer with the KVP Company Limited, Espanola, Ont.

S. Lake, JR.E.I.C. (B.Eng., civil, McGill 1955) has been appointed president and director of Secant Construction Company, Montreal, Que.

Robert L. Blackie, S.E.I.C. (B.Eng., mech., McGill, 1963) formerly of Montreal is now living in England.

Donald G. Delparte, JR.E.I.C. (B.Eng., civil, Saskatchewan 1958) has been appointed district engineer with the Saskatchewan Municipal Road Authority, Saskatoon, Sask.

Jean-Claude Hebert, S.E.I.C. formerly with the Canadian Broadcasting Corporation has left there to join a Consulting Engineer Bureau in Montreal.

knows the breaking point

Knowing the performance ability of steel plate structures, BEFORE THEY ARE BUILT, is the key to quality construction. This thoroughness of applied metallurgical research is why Horton fabricate the big and unusual contracts, many of a 'first-time' nature in Canada.

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The first step in 'knowing' is of a 'destructive' nature, testing base and welding materials, such as electrodes and flux. Breaking test welds under sub-zero temperatures on an impact machine to determine whether the weld and base material is capable of absorbing energy at low temperatures, is but one example. The result of this test—and many others—is the setting of pre-determined standards.

As fabrication commences, quality control systems progressively examine all phases of construction, maintaining pre-determined standards. On the finished structure,'non-destructive' tests such as radiography and others, are additional checks on quality. And, as final proof of quality, the vessel or tank may be tested beyond its normal working pressure.

No expert can foretell the strength of steel plate just by looking. But Horton, with their extensive facilities and skill, use all techniques for finding out. Whatever your requirements in steel plate—regardless of future code or specifications—Horton is ready to meet those demands—in new techniques, special alloys and clad materials. For information, or tenders, write our nearest office.

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NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute and abstracts of the papers presented at their meetings

BAIE COMEAU

G. W. Scott, M.E.I.C., *Correspondent*

CANADA'S ATOMIC ENERGY PROGRAM was discussed by W. J. Bennett, executive vice-president and general manager of Canadian British Aluminium Company Limited, at a meeting on April 29, 1959.

In the speaker's opinion it would be at least 25 years before atomic power is likely to supersede hydro-electric power economically in places like the province of Quebec. This does not exclude the use of atomic power as a supplement to conventional sources of power in the near future, particularly where fuel transportation or transmission costs are high.

BELLEVILLE

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

C. E. CARSON, director of Imperial Oil, Toronto, presented his ideas on Energy and Progress on April 13, 1959 at the branch annual meeting.

Mr. Carson said that Canada, now traditionally known as a supplier of raw materials, is rapidly becoming an industrial nation, with an increasing demand for energy. With the power used per capita in the U.S.A. based on 100, Canada uses about 89% per capita, which is 6 times the world average. Projections have been made for 1980 at 2½ times the 1957 consumption. Mr. Carson also said that Canada has an abundant fuel supply for the foreseeable future.

Officers for 1959-60, elected at this meeting are: chairman, W. C. Benger, vice-chair., H. T. Floyd, secretary-treasurer, F. E. Moore, executive committee, T. J. McGaid, D. A. Law, W. G. N. Throop, E. Hilbig, V. L. Lewis, and W. T. Caniff.

BORDER CITIES

R. L. Kennedy, M.E.I.C., *Correspondent*

THE ADVANTAGES OF BEING AN ENGINEER were recounted at the meeting of March 19, by A. W. F. McQueen, president of the A.P.E.O., and president of H. G. Acres & Co.

Mr. McQueen was introduced by C. T. Carson, a classmate, and immediate past president of A.P.E.O.

THE LAW AND ENGINEERS was the topic which proved to be of great interest at the meeting of April 16. As presented by Judge Joseph A. Legris, judge of Essex County, Windsor, this was a general explanation of how the law affects a citizen. It was liberally sprinkled with anecdotes and humour.

Judge Legris is also an engineer.

At Border Cities meeting: C. T. Carson, A. W. F. McQueen, and Chairman J. Earl Dykeman.

CENTRAL BRITISH COLUMBIA

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

WHAT THE LAW IS, and What You Can Expect from a Lawyer was the subject covered at the May 1, 1959 meeting. Speaker was P. Van der Hoop, of the law firm, Boyle, Aikens, O'Brian & Co., Penticton.

The history of English law, and the developing of case law, were discussed. There are duties placed upon the engineer in the exercise of his skill and knowledge, which the speaker described, giving examples.

M. L. Wade reported to the meeting on the plenary meeting held in Toronto. He also reported on a visit to Chalk River.

CHALK RIVER

C. E. Lawrence Hunt, JR.E.I.C., *Correspondent*

PRESIDENT K. F. TUPPER OF THE E.I.C. visited this branch on April 24. He addressed the meeting on the recent trip he and Dr. Page took to Russia in an attempt to arrange exchange of visits between Russian and Canadian engineers.

He gave his impressions of the engineering training in Russia and a brief description of living conditions in Moscow and Leningrad.

THE NEW EXECUTIVE for the 1959-60 season have been confirmed. They are: chairman, C. E. L. Hunt, sec.-treas., W. O. Findlay, program chairman, A. H. Wilson, membership, G. R. Fanjoy, and district representative, J. S. Flavelle.

CORNWALL

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

EDUCATION IN THE U.S.S.R. was the subject of a talk on April 15, 1959, by Alexei S. Tovstogan, second secretary of the Russian Embassy, Ottawa.

His audience of 92 was made up of members, ladies, and representatives of school boards, school inspectors and principals.

PETERBOROUGH

J. G. Hooper, M.E.I.C., *Correspondent*

LEONARD MARION was the speaker at the meeting of February 10 on the subject Hydro Electric Power Generation. Mr. Marion is a specialist at Hydro Electric Power Generation for Canadian General Electric Co., Peterborough.

Mr. Marion said that at the end of 1957 the United States was the greatest user of hydro-electric power in the world, and Canada was second, using 15% of world total or 8 times the world average. Of hydro and steam power Canada was second highest user per capita, following Norway and followed by U.S.A. In recent years which have seen a labour and materials costs increase of about 140 per cent, cost increase of Canadian built generators was 60 per cent due to improved technology and refinements. Reliability is important to avoid outages and loss of revenue.

EASTERN TOWNSHIPS

JEAN BOURASSA, JR.E.I.C., *Correspondent*

WALTER H. TREML, sales engineer, Viditon Corporation, Ottawa, was the speaker on April 17, 1959, his subject being A Down to Earth Approach to Aerial Photogrammetry.

He explained the difficulties encountered by the pioneers: relatively high cost of chartering planes, exacting performance required from cameras. Some

• BRANCH NEWS

applications of photogrammetry were illustrated by slides, as well as various instruments.

A buffet supper was served to the 46 members attending this meeting.

EDMONTON

I. G. Finlay, M.E.I.C., *Correspondent*

A NEW EXECUTIVE was elected at the annual meeting of April 23. S. R. Sinclair, chairman; J. Longworth, vice-chairman; executive members, C. R. McFadyen, A. W. Peterson, B. A. Ellis, D. B. Smith, I. G. Finlay, L. C. Moon, C. A. McNeill, A. Sandilands; secretary-treasurer, G. Hodge.

FREDERICTON

L. W. Smith, JR.E.I.C., *Correspondent*

THREE STUDENTS from the University of New Brunswick spoke at the meeting of April 20. They were Paul Como, of civil engineering, on Fredericton Traffic Problems, Possible Solutions; Allister MacLelland, of mechanical engineering, on Spark Erosion in Metal Processing; Paul Stewart, of electrical engineering, on Automatic Railway Signalling.

Paul Stewart was chosen as the winner of the speaking contest.

Election of branch officers took place at this meeting with the following results: chairman, W. L. Barrett; vice-chairman, H. E. Marshall, secretary, Eric Garland, treasurer, Carman Bliss, committee, John Burrows, Tim Bliss, and G. R. MacLaughlin.

LAKEHEAD

G. O. Hansen, JR.E.I.C., *Correspondent*

BRAIN STORMING TECHNIQUES were discussed on April 29 by R. F. Howsan, supervisor of industrial relations for the Fort William plant of the Canadian Car Corporation.

Brainstorming is a means of stimulating thought and action on problems that confront us. These methods have been used to solve many problems. One method is to assemble a small group of six to eight persons, to whom the problem is accurately described. Each individual, after a minute's thought gives his idea of a solution. These ideas are recorded and read back to the group, from the lot a master suggestion is adopted. The feeling of urgency in having to come up with an idea within a minute tends to overcome the fear of making a ridiculous suggestion.

McGILL UNIVERSITY

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

DR. K. F. TUPPER, president of the Engineering Institute spoke to some 300 students in a general meeting of the McGill University Undergraduate Society on February 27. Taking as his subject, The Engineering Graduate, Dr. Tupper emphasized the value of the young engineer's personality and general outlook on life as factors in his success in later life.

MONTREAL Junior Section

B. Michel, JR.E.I.C., *Correspondent*

THE ANNUAL MEETING took place on January 26. A review of the various committees was given, and of special interest were the results of a survey of the wants and needs of the junior membership.

A total of 403 answers were received. Of these, 33 per cent indicated preference for technical lectures in the member's own field, and 23 per cent a preference for non-technical lectures. Social activities were given second place.

Officers were elected, as follows: chairman, J. Dubuc, vice-chair., R. Walker, sec-treasurer, B. Lamare, councillors, D. A. Jackson, D. Pollock, L. H. Lafontaine, J. Tetreault, J. G. Garneau, P. Arsenault, B. Michel.

A MEETING ON FEBRUARY 16 featured a talk on Sporting Dogs by P. Ouimet and B. Lapper. An excellent film illustrated training of dogs for hunting.

THE MONTREAL-LAURENTIAN AUTOROUTE was discussed by A. O. Mathieu, on March 16. Mr. Mathieu, chief engineer of the Autoroute, gave technical information and details of the operating organization of the autoroute.

• BRANCH NEWS

Student Guidance

J. A. Randle, M.E.I.C., *Correspondent*

Two FORUMS are held each year under the sponsorship of the student guidance committee. One is for the English speaking students and one for French speaking students.

On February 12, at E.I.C. headquarters, W. A. Marshall, M.E.I.C., spoke on Careers in Engineering. On March 15, at Ecole Polytechnique, Bernard Lachapelle spoke on "Expose General sur la profession d'Ingenieur". Mr. Marshall is president of the Dominion Structural Steel of Montreal and Mr. Lachapelle is in charge of special services for the Corporation of Professional Engineers of Quebec.

At a question period, the students are invited to question the speaker and other engineers who join him for this part of the meeting.

NIPISSING AND UPPER OTTAWA

D. J. Thornton, S.E.I.C., *Correspondent*

THE ANNUAL MEETING of the branch was held on April 15, 1959.

These officers were elected for the coming year: chairman J. M. Rosborough, vice-chairman, T. H. Chapman, executive committee: C. A. Hellstrom, D. Cunningham, P. Rebin, H. Staniforth, D. W. Briden, G. M. Goodreid. The secretary-treasurer was to be appointed by the new executive.

Three members of the branch gave short addresses on their occupations. Richard Booy of Canadian International Paper Company, Temiskaming, spoke on Canada's Second Oldest Electrolytic Chlorine Plant; B. W. Kelly, of Dupont of Canada, North Bay, on The Manufacture of Commercial Explosives, and R. S. MacLennan, a consulting engineer, on Municipal and Town Planning.

DATES TO REMEMBER

AUGUST 11, 12, 13, 1959

NOVA SCOTIA TECHNICAL COLLEGE

50th Anniversary Reunion

For information write Box 811, Halifax, N.S.

NOVA SCOTIA TECHNICAL COLLEGE

Donald Kelly, S.E.I.C., *Correspondent*

AT THE RECENT ANNUAL MEETING of the Student Society, Donald Kelly was elected president for the coming year.

NORTHERN NEW BRUNSWICK

S. K. Henry, JR.E.I.C., *Correspondent*

E. J. LUTZ, spoke at a meeting on April 25 on The Growth of Canada, tracing the history and economic growth since Confederation. Mr. Lutz is a former manager of the Bank of Nova Scotia, at Newcastle, N.B.

This was a general meeting of the branch, at which nominations of officers for the year 1959-1960 were presented. The result was the following slate of officers: chairman, P. J. Delicaet; vice-chairman, V. G. MacWilliam; sec.-treasurer, Peter Dallien; executive, G. A. Bird, P. E. Desserud, R. E. Haines, R. A. Cameron. The annual meeting was announced for May 29, at Bathurst, N.B.

• BRANCH NEWS

OTTAWA

D. R. Grimes, M.E.I.C., *Correspondent*

G. W. STEAD spoke at a meeting of April 2 on the subject of Ice Breaking in the St. Lawrence. Mr. Stead is Director of General Marine Services Branch, Department of Transport.

Icebreaking prevents flooding in the Montreal area, and is also used to aid spring and fall shipping. The ice conditions this spring were the worst in 25 years. Some of the Department's problems and methods were described.

THE FOURTH ANNUAL ARCHITECTS-ENGINNEERS DANCE was held on March 19. About 160 architects, engineers, and their wives were received by Mr. and Mrs. John S. Watt, chairman of the Ottawa Branch, and Mr. and Mrs. Darcy Helmer, chairman of the Ottawa Chapter, Ontario Association of Architects.

PETERBOROUGH

J. G. Hooper, M.E.I.C., *Correspondent*

CHAMPAGNE DINNER DANCE was the third annual ladies' night event. It was held at Kawartha Golf and Country Club on Friday, April 24, 1959.

The menu was in the French manner. L. H. Mensforth was in charge of arrangements.

SASKATCHEWAN

W. A. Friebel, M.E.I.C., *Correspondent*

THE SASKATOON SECTION acquired on March 20, at its annual meeting a new executive by a new procedure. An elected committee has become the ex-executive.

The officers are: chairman, Paul Riemer, vice-chairman and treasurer, Dick Strayer, secretary, Fred Catterall, publicity, Vern Friebel, committee members, Morris Cherney, Roger Dupuis, Tom Greenaway, Don Kelly, Nick Peters, ex-officio, Ernie Cole and Bob McCullough.

G. HONDEGORD, of National Research Council, Saskatoon, spoke at the meeting of April 18, giving a commentary on the film "Setting Fires for Science".

The N.R.C. division of building research is continually conducting fire experiments, and as a result the national building code has been changed.

SARNIA

Murray Waghorne, M.E.I.C., *Correspondent*

THE CANADIAN AIRCRAFT INDUSTRY was considered by a meeting of the branch on February 17. M. D. Willer, Sales and Service Manager, Avro Aircraft Ltd., Toronto, was the speaker. After a review of the history of aviation in Canada, the present mature state of the industry was demonstrated by a coloured film covering the development of the Avro Arrow.

CAPE BRETON

H. M. Aspinall, M.E.I.C., *Correspondent*

BRIAN HANSON, of Imperial Oil Co., Sydney, N.S., was the speaker on April 29, and his subject was Lubrication Oils.

He outlined development of desirable properties in lubricating oils, detergent, anti-corrosion additives, etc. A small engine was used to demonstrate the acidic property of exhaust gasses and the use of proper oils to prevent corrosion.

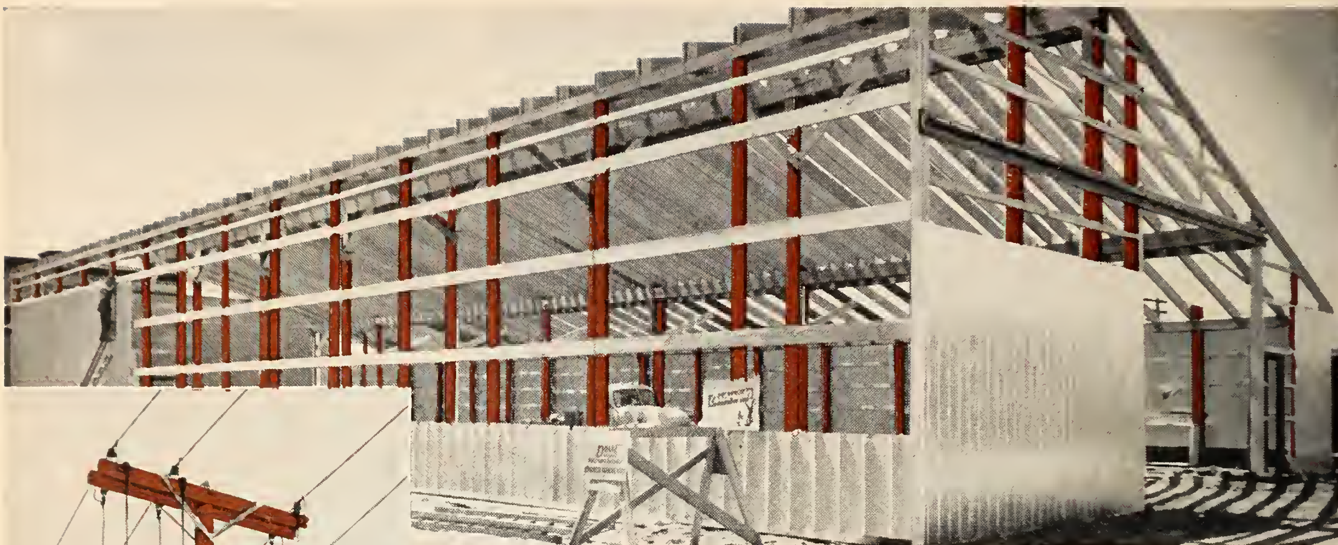
CARLETON UNIVERSITY

Thomas A. West, S.E.I.C., *Correspondent*

ROCKETRY presents problems which must be overcome before space travel becomes feasible. A paper was presented on March 27, by Dr. John Hart, associate professor in the Department of Physics, Carleton University, in which the human engineering aspect was examined. Design for the needs of the human body, and for extreme accelerations offer difficulties, which the speaker treated in an interesting and humorous talk. The constitution of the Engineering Society was considered, and passed by a majority vote on March 16.

ELECTIONS TOOK PLACE on April 7, with these officers elected by acclamation: president, Fred King, vice-president, Keith Stoodley, social convenor, Alan Webster, Tours and talks convenor, Elihu Edelson, secretary-treasurer, John Roll, public relations officer, Tom West.

Vancouver Branch. E.I.C. president and general secretary, K. F. Tupper and G. T. Page, on a visit to the R.C.S.M.E. at Chilliwack, B.C. In the picture, seated: Mrs. Page, Mrs. Heslop, Mrs. Tupper, Mrs. Carson, Mrs. Davy; standing: Mrs Boivin, Lt. G. Boivin, Mrs. Freeborn, Col. R. J. Carson, Prof. W. Heslop, Dr. Tupper, Dr. Page, Commodore A. C. M. Davy, Mrs. Wyld, Capt. R. C. Wyld, and Major F. R. Freeborn.



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• BRANCH NEWS

SAULT STE. MARIE

R. J. Saunders, S.E.I.C., *Correspondent*

FORESTRY ENGINEERING was discussed by J. Lockwood, district forester, Dept. of Lands and Forests, Sault Ste. Marie, on April 10, 1959.

Growth of the forestry profession since the thirties was pointed out by the speaker, and the foresters' work in nurseries, fire protection, public relations, timber rights, and logging management. More foresters are needed to insure the forest economy, Mr. Lockwood said. There must be cooperation between the forester, the government and industry.

WINNIPEG

P. M. Abel, JR.E.I.C., *Correspondent*

THE DEAS ISLAND TUNNEL was described to a branch meeting on March 19, by N. D. Lea, vice-president, Foundation of Canada Engineering Corporation Limited.

The subject matter was the paper published in the April issue of the Journal, and was illustrated by slides and film.

A PLANT VISIT was arranged for April 16. Members visited the new Griffin Steel Foundries Ltd., in Transcona, Manitoba, with members of the Illuminating Society.

Civil Section

H. B. McLenaghan, JR.E.I.C., *Correspondent*

REGULATION of Lake Winnipeg and Lake Manitoba for flood control was outlined by Ed Kuiper, former chief engineer of the Lakes Winnipeg and Manitoba board at the January meeting of the civil section.

The flood control investigations included a control dam on the Assiniboine River, a cut-off channel from the Assiniboine to Lake Manitoba, deepening of the Red River channel in the vicinity of the St. Andrews rapids and also a diversion channel of the Seine River to the east around Winnipeg. The latter method of control was concluded to be the most advantageous and economical.

R. M. DILLON, M.E.I.C., spoke on February 12 on the subject "Some Aspects of the Design of Structures of the South Perimeter Route of the Metropolitan Winnipeg By Pass, Trans Canada Highway". Mr. Dillon is a structural director, M. M. Dillon & Co., Consulting Engineers, London, Ont.

The Assiniboine River Bridge substructure has four piers and two abutments carried on spread footings founded on hardpan. The superstructure is a composite design consisting of all welded structural steel built up girders carrying a 7½-inch reinforced concrete slab.

(Continued on page 163)

LIBRARY NOTES

ADDITIONS TO THE INSTITUTE LIBRARY • REVIEWS • BOOK NOTES • STANDARDS

BOOK 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.

*TRANSISTOR TECHNOLOGY: VOLUME II

Part one discusses the technology of materials with special emphasis on silicon. Part two deals with the principles of device design beginning with diodes, and continuing with triodes and the more complex multiple junction switching devices and tetrodes. Chapters follow on radiation sensitive devices, field effect devices, and on noise behavior. The book concludes with the design implications of surface phenomena. (F. J. Biondi, ed. Toronto, Van Nostrand, 1958. 701p., $19.00.)

*TRANSISTOR TECHNOLOGY, VOLUME III

This, the latest volume of an extensive work, deals with the preparation of junctions; fabrication technology, including such processes as etching, alloying and diffusion, photoengraving techniques, and procedures for making contacts; information on measurement and characterization; laboratory and field use reliability. The material is equally divided between that of a general nature and that which is specific to germanium and silicon. (F. J. Biondi, ed. Toronto, Van Nostrand, 1958. 416p., $13.50.)

*DIGITAL TECHNIQUES FOR COMPUTATION AND CONTROL

A survey of the basic techniques used for digital computation and control, including code arithmetic, logical networks, multiplexing, conversion, data reduction, digital process control, two-terminal relay circuits, counting techniques, digital computers of all types, computer programming, digital differential analyzers, and combined analog-digital equipments. Descriptions of components and available commercial equipments add to the value of the book. (M. L. Klein and others. Pittsburgh, Instruments Publishing Co., 1958. 394p., $6.00.)

*PHILOSOPHY OF STRUCTURES

Discusses the basic concepts of advanced structural design as developed by Torroja, including such factors as the nature of stress in different types of structures; the proper use of materials; structural elements; design of retaining structures, roofs, floors, bridges, and aqueducts; construction methods and their influence on design and cost; the role of calculations and experimental stress analysis; the function of the designer in the construction enterprise. (E. Torroja. California, University Press, 1958. 366p., $12.50.)

*MODERN MATERIALS: ADVANCES IN DEVELOPMENT AND APPLICATIONS, VOL. 1

This volume, which is the first in a series, covers a variety of materials and the recent developments in connection with them: zirconium; the semiconductors, germanium and silicon; ceramic engineering materials and their applications; insulating papers for high voltages; glasses required to withstand strong irradiation in nuclear engineering; synthetic rubbers for special purposes; new areas of wood as a structural material; organic and inorganic fibres. (H. H. Hausner, ed. New York, Academic Press, 1958. 402p., $12.50.)

*THE TRANSURANIUM ELEMENTS

The author begins with the discovery of plutonium in 1940 as the result of the bombardment of natural uranium with deuterons in a cyclotron. He then discusses the chemical properties of the actinide elements, ranging from thorium to Mendelevium. The concluding portions of the book are concerned with the nuclear properties of the transuranium elements and the possibilities for new elements. A volume in the Atoms for Peace presentation set. (G. T. Seaborg. Reading, Addison-Wesley, 1958. 328p., $7.00.)

*U.S. RESEARCH REACTOR OPERATION AND USE

Studies the research reactor as a means of providing a strong source of neutrons and gamma rays for physical research, irradiation testing, and producing radioactive isotopes. The principal emphasis in the book is on the advantages and disadvantages of different reactors and on the costs of acquiring and operating a research reactor facility. Each type of research reactor is described in detail and analyzed in relation to specific needs. A volume in the Atoms for Peace presentation set. (J. W. Chastain, Jr., ed. Reading, Addison-Wesley, 1958. 366p., $7.50.)

*URANIUM ORE PROCESSING

A description of the technology utilized in extracting uranium from its ores. The book covers preliminary treatments like roasting and physical concentrations, leaching with acid or alkaline reagents, separation of the pregnant leach liquor from the unwanted solid gangue, and recovery of the uranium product from the solution, principally by ion exchange and solvent extraction. Six typical plants are then analyzed in considerable detail to illustrate these processes. The book concludes with minor sources of uranium ore such as shale, lignate and phosphate rock. A volume in the Atoms for Peace presentation set. (J. W. Clegg and D. D. Foley, eds. Reading, Addison-Wesley, 1958. 436p., $7.50.)

*TOOLS FOR MACHINE LITERATURE SEARCHING

An extensive work which represents the results of a considerable amount of experimentation over the past five years. The book is presented in four parts, of which the first two deal with machine literature searching systems in general and their basic underlying principles. In the third part, procedures developed by the authors are given for analyzing, encoding, and searching of record information. The concluding section consists of a semantic code dictionary with directions for its use. (J. W. Perry and A. Kent. New York, Interscience, 1958. 972p., $27.50.)

ROCKET TO THE MOON

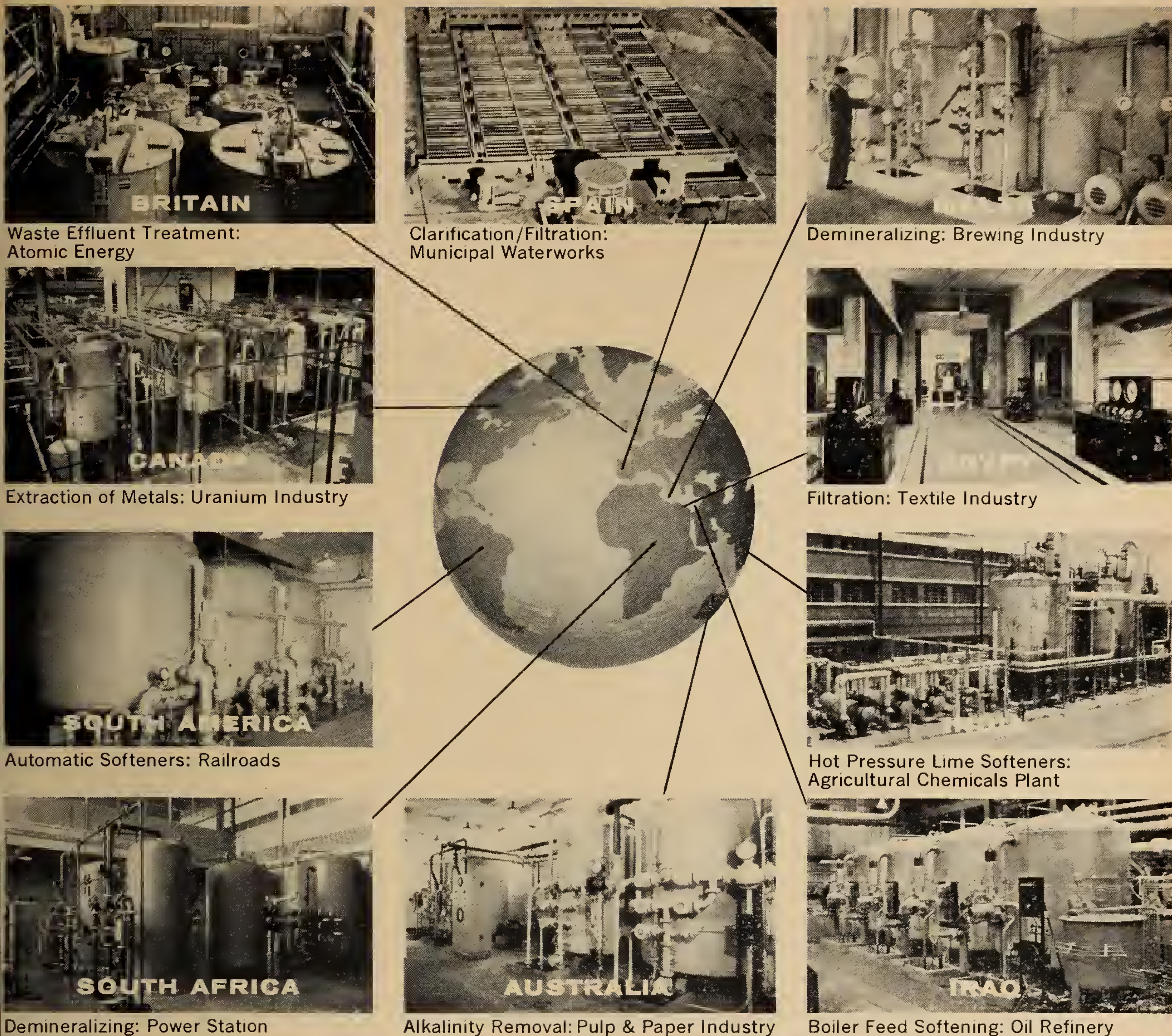
A compilation of ideas, thoughts, facts, guesses and assumptions on man's conquest of the moon, and the possible effects of that conquest. The authors, Americans, are convinced that it is possible to reach the moon, and critical of their country's space policies. They include information on the accomplishments of both the U.S. and the U.S.S.R. in this volume, intended primarily for laymen. (E. Bergaust and S. Hull. Toronto, Van Nostrand, 1958. 270p., $5.95.)

*SYMPOSIUM ON EFFECT OF OZONE ON RUBBER

Papers on various facets of the effect of ozone attack on rubber, particularly polybutadiene rubbers and elastomers. Also considered are preventatives such as chemical antiozonants, and the use of waxes. These papers were presented at a meeting held in St. Louis, Mo., in 1958. (Philadelphia, American Society for Testing Materials, 1958. 130p., $3.75. Stp. 229.)

*CHEMICAL PROCESSING OF NUCLEAR FUELS

An introduction to the problems of chemical processing of the fuel after it


BRITAIN
Waste Effluent Treatment: Atomic Energy
SPAIN
Clarification/Filtration: Municipal Waterworks
Demineralizing: Brewing Industry
Extraction of Metals: Uranium Industry
Filtration: Textile Industry
SOUTH AMERICA
Automatic Softeners: Railroads
Hot Pressure Lime Softeners: Agricultural Chemicals Plant
SOUTH AFRICA
Demineralizing: Power Station
AUSTRALIA
Alkalinity Removal: Pulp & Paper Industry
IRAQ
Boiler Feed Softening: Oil Refinery

has been irradiated in a reactor. Following introductory materials, the major part of the book deals with aqueous processes, including solvent extraction, ion exchange, and precipitation processes; and with non-aqueous processes including distillation of metals, extraction by liquid metals, fluoride volatilization, and separations based on chemical reactions. Concluding sections deal with effluent disposal and fission product recovery, and with trends in nuclear fuel processing. (F. S. Martin and G. L. Miles. Toronto, Butterworth, 1958. 242p., $7.50.)

°GLOVE BOXES AND SHIELDED CELLS FOR HANDLING RADIOACTIVE MATERIALS

Papers dealing with radiation shielding which are based mainly on British practice. Part one is concerned with unshielded boxes and discusses safety, general design and manufacture, constructional materials, decontamination, layout in laboratories, provision of inert atmospheres, handling of polonium, operations with gaseous materials, and large scale operations. Part two deals with shielded cells, and discusses shielding calculations, viewing and handling equipment, design of shielded cells as well as operations on beta-ray emitters, plutonium, multicurie caesium sources, and irradiated fissile materials. These papers comprise the proceedings of a Symposium held at Harwell, England, in 1957. (G. N. Walton, ed. Toronto, Butterworth, 1958. 515p., $16.80.)

°A HANDBOOK ON TORSIONAL VIBRATION

An extensive work which gives formulas, design procedures, specifications and methods relating to torsional vibration conditions of engines and machines. The four major divisions presented encompass preliminary calculations and measurements, evaluation and prediction of torsional vibration stresses, design and operation of various devices for limiting vibration, and instrumentation. Each subsection on design procedure or testing is self-contained so as to provide maximum usability of the handbook. (Comp. by E. J. Nestorides for the British Internal Combustion Engine Research Association. Toronto, Macmillan, 1958. 664p., $18.70.)

°FINE PARTICLE MEASUREMENT

A discussion of the important techniques currently used in research laboratories for the measurement of size, surface and pore volume. The basic principles, construction and use of apparatus, methods of data analysis, applications, and limitations are given for such techniques as automatic scanning, the fixed-time method, the Hauser/Lynn method, gravimetric analysis, and liquid-phase sorption. An extensive biliography of approximately 400 references is included. (C. Orr and J. N. Dalla Valle. Galt, Brett-Macmillan, 1959. 349p., $10.50.)

°SCALE-UP IN PRACTICE

A unified review of the various aspects of pilot plant problems. Among the topics discussed are the factors justifying the operation of pilot plants, a review of scale-up theory, simulating operation of processes and equipment with computers, the hazards involved, the process and business economics of scale-up, and organization. (R. Fleming, ed. New York, Reinhold, 1958. 134p., $4.50.)

°WATER POWER ENGINEERING

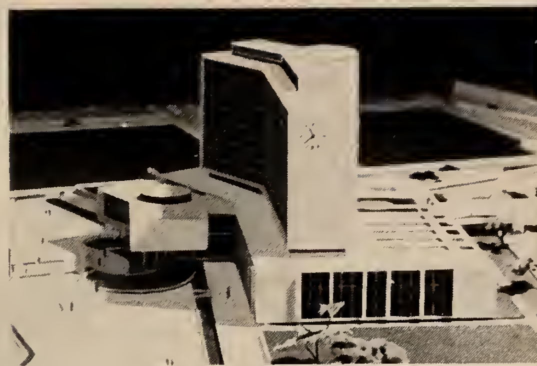
Begins with a survey of the water power industry and such aspects as planning, underground power stations, geological factors, and the relationship between water and nuclear power. The main types of turbines are then studied with stress on full scale and model tests and on cavitation. Such electrical problems as insulation, high voltage transmission, voltage regulation, and cables are also considered. (R. Hammond, Galt, Brett-Macmillan, 1958. 302p., $10.00.)

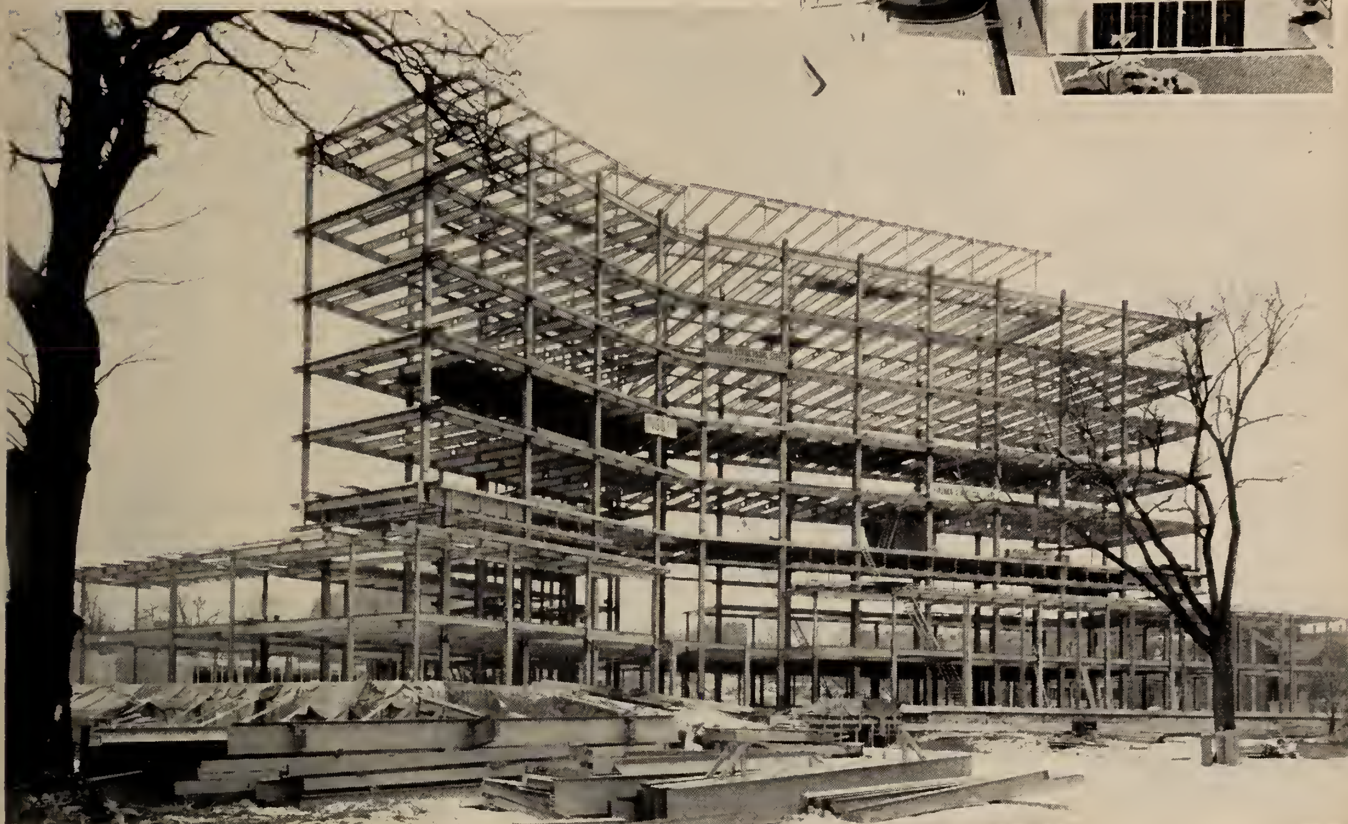
°GAS CHROMATOGRAPHY 1958

Twenty-eight papers are presented and divided into three sections dealings with theoretical and experimental aspects of gas chromatography, recent trends and new developments in techniques and apparatus, and various applications of gas chromatography. These papers comprise the proceedings of the second symposium organized by the Gas Chromatography Discussion Group and held in Amsterdam in May, 1958. (D. H. Desty, ed. Toronto, Butterworth, 1959. 383p., $13.00.)

°PHYSICAL LAWS AND EFFECTS

A compilation which provides a brief description of approximately 100 familiar and unfamiliar laws and effects, an indication of their expected magnitude, and references to further sources of information. The book is intended as a source of useful concepts in research de-





• LIBRARY NOTES

velopments, and among the varied topics included are the Barkhausen effect, luminescence, Bremstrahlung radiation, Curie-Weiss law, thermoelectric effects, memory metals, stress-strain effects, etc. (C. F. Hix and R. P. Alley. New York, Wiley, 1958. 291p., $7.95.)

*ELEMENTS OF ENGINEERING STATICS

Covers the problem of equilibrium, equilibrium of simple planar systems, equivalence of force systems, simple structures, sliding friction, work and energy methods, and equilibrium of simple spatial systems. The techniques of vector algebra are employed to develop rigorously the fundamental theorems, results, and methods of statics and to apply these to the solution of engineering problems. An extensive appendix consists of problems to illustrate the principles of the text. (H. Deresiewicz. Toronto, Oxford, 1958. 124p., $3.75.)

*AMERICAN POWER CONFERENCE. PROCEEDINGS, VOLUME XX

Papers dealing with varied aspects of the generation, transmission, and utilization of power. Among the topics discussed are steam and gas turbines, water technology;. hydroelectric power; nuclear power development; industrial plants; central stations; transformers; extra-high voltage systems; distribution equipment; fuels; heating, ventilation and air conditioning; computers and network analyzers. (Chicago, Illinois Institute of Technology, 1958. 748p., $8.00.)

*A HISTORY OF TECHNOLOGY, VOL. V: THE LATE NINETEENTH CENTURY, c.1850—c.1900

The importance of applied science and its effect on manufacture and production in the latter half of the nineteenth century is the outstanding theme of the present volume which concludes the series. Also considered is the social effect of scientific industry upon the lives of individuals. Topics presented include primary production, prime movers, the chemical industry, transport, civil engineering, and manufacture. (Ed. by C. Singer and others. Toronto, Oxford, 1958. 888p., $25.50.)

*MECHANICAL ENGINEERS' HANDBOOK, 6TH ED.

This new edition of a standard handbook previously edited by Lionel S. Marks, covers virtually every aspect of mechanical engineering. Theory, standards, and practice are compiled by over 90 persons, each a specialist in the area covered. Substantial revisions or additions include sections on numerical analysis and computing machines, vibrations, aerodynamics, jet propulsion, atomic power, automobiles, instruments and controls, railway engineering, corrosion, turbo compressors and gas turbines, lubricants and lubrication, and welding. (T. Baumeister, ed. Toronto, McGraw-Hill, 1958. Various pagings, $23.40.)

STANDARDS RECEIVED

ASTM standards. American Society For Testing Materials, 1916 Race St., Philadelphia 3, Pa.

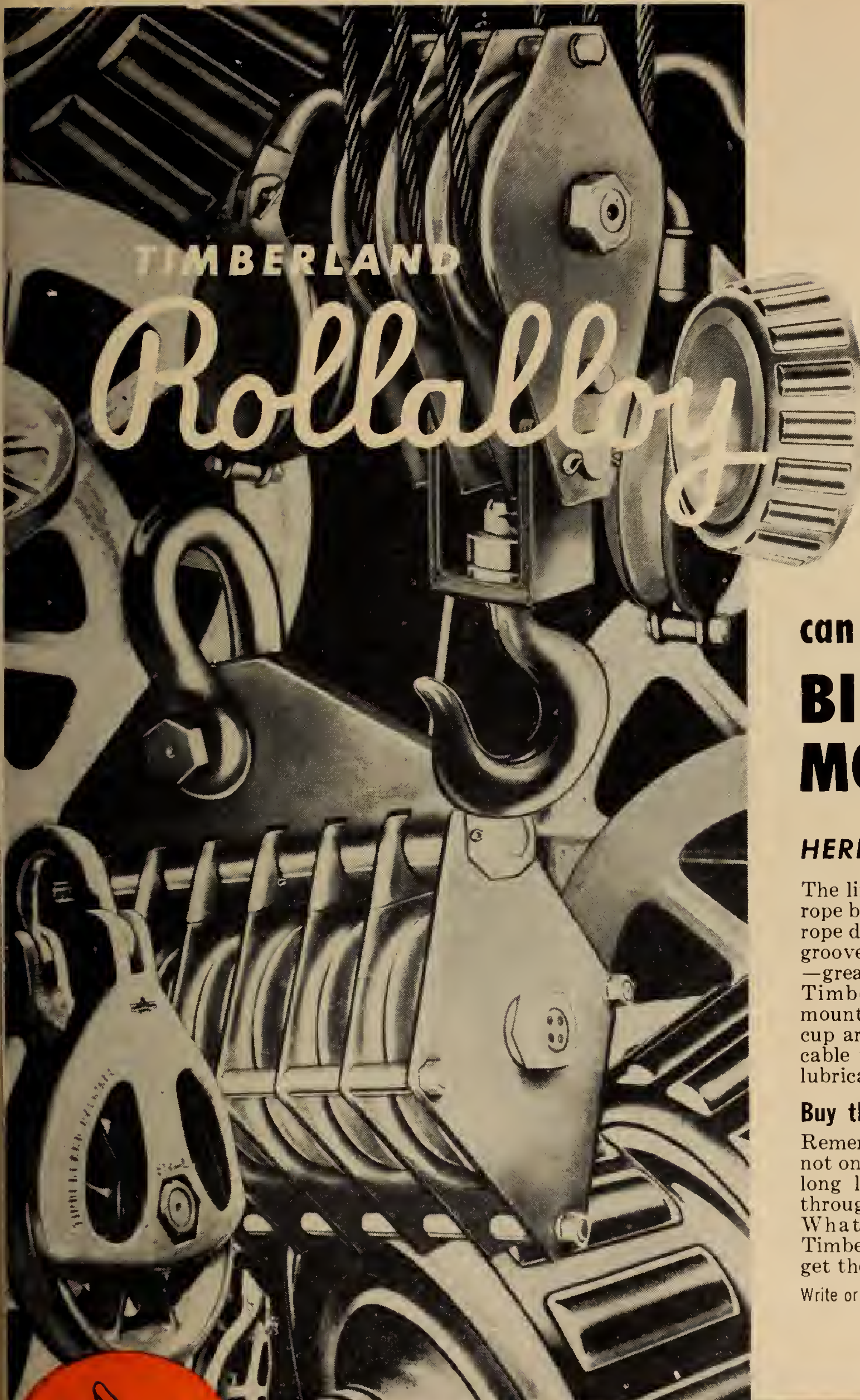
ASTM standards on cement. $3.50
ASTM standards on soaps and other detergents. $3.50
ASTM standards on textile materials. $7.50

*BOOK OF ASTM STANDARDS, 1958

The triennial compilation of ASTM Standards, expanded in this edition from seven to ten parts occupying 13,600 pages. A total of 2,450 standard specifications, methods of test, definitions of terms, and recommended practices are included in the various sections which deal with ferrous metals specifications; non-ferrous metals specifications; methods of test for metals; cement, concrete, mortars, road materials, waterproofing, soils; masonry products, ceramics, thermal insulation, sandwich and building constructions, acoustical materials, fire tests; wood, paper, adhesives, shipping containers, cellulose, leather; petroleum products, lubricants, tank measurements, engine tests; paint, naval stores, aromatic hydrocarbons, coal, coke, gaseous fuels, engine antifreezes; plastics, electrical insulation, rubber, carbon black; textiles, soap, water, atmospheric analysis, wax polishes. The volumes are available separately. (10 vols. $116.00.)

Canadian Standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2.

A31-1959: Code for modular coordination in building. $1.00
A145-1959: Rubber floor tile. 75c
B131.11-1958: Universal cast iron pipe



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C22.2 No. 64-1959: Construction and test of domestic cooking and liquid-heating appliances. 3rd ed. $1.50

C22.2 No. 86-1959: Construction and test of service equipment. $1.25

C22.2 No. 113-1959: Construction and test of fans and ventilators. $1.25

G40 Series: Specifications for structural steel.

0141-1959: Specification for yard lumber. 75c

C2-1959: Single-phase distribution transformers types ONS and LNS, 4th ed. $1.00.

C22.2 No. 118-1959: Construction and test of picture machines and appliances. $1.00.

C22.3 No. 1.5-1959: Heights of conductors above ground. $1.00.

Underwriters' Laboratories of Canada standards. Underwriters' Laboratories of Canada, 7 Crouse Rd., Scarborough, Ont.

List of inspected appliances, equipment, and materials; September, 1958.

Indian Roads Congress, Jamnagar House, Mansingh Rd., New Delhi-2.

Standard specifications and code of practice for road bridges. Section 2: Loads and stresses.

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Acoustics

Acoustical design of the Alberta jubilee auditoria, by T. D. Northwood and E. J. Stevens. Ottawa, N.R.C., Div. of Bldg. Research 1958 (Research paper no. 70)

Alberta. Economic survey.

"Alberta"—Province of opportunity. Calgary, Calgary Power Ltd., 1958.

Amplifiers

Video amplifiers, ed. by A. Schure. New York, Rider, 1959. $1.80.

Atomic energy

Canadian atomic energy development in review and prospect, by Dr. W. B. Lewis. London, Institution of Mechanical Engineers, 1958.

Fundamentals of nuclear energy and power reactors, by H. Jacobowitz. New York, Rider, 1959. $2.95.

Banking

100 years of banking in Canada; a history of the Toronto-Dominion bank, by J. Schull. Toronto, Copp Clark, 1958.

Bibliographies

Annotated bibliography on lateral loads on unreinforced masonry walls, comp. by D. E. Allen. Canada, N.R.C., Div. of Bldg. Research, 1958. No. 14. Construction estimating, management, and cost accounting, comp. by E. Carson. Ottawa, N.R.C., Div. of Bldg. Research, 1959. No. 15.

Buildings. Design

How to design pole-type buildings, by D. Patterson. Chicago, American Wood Preservers Institute, 1958. $1.50

Canada. Engineering manpower.

Recent changes in engineering manpower requirements and supplies in Canada. Ottawa, Dept. of Labour, Economics and Research Branch, 1959. (Professional manpower bulletin no. 4) 25c

Canada. Minerals

Milling plants in Canada; industrial minerals.

Metallurgical works in Canada; non-ferrous and precious metals. Both: Ottawa, Dept. of Mines and Technical Surveys, Mineral Resources Division, 1958. 25c each.

Canada. North West Territories.

The National Northern Development Conference and the post-conferen e air tour. September 17-21, 1958. Edmonton, Alta., Chamber of Commerce, 1958. $3.00.

Concrete

Design of eccentrically-loaded columns by the load-factor method, by J. D. Bennett. London, Concrete Publications, 1958. $1.90.

Loading tests on reinforced concrete slabs spanning in two directions, by A. J. Ockleston. Johannesburg, Portland Cement Institute, 1958. (Paper no. 6)

Design of rectangular beams and slabs, by J. S. Cohen. London, Concrete Publications, 1957. $1.00.

Calorimeter-strain apparatus for study of freezing and thawing concrete, by G. Verbeck and P. Klieger. Chicago, Portland Cement Association, 1958. (Research department bulletin 95)

Danish National Institute of Building Research. Committee on alkali reactions in concrete. Progress reports:

B3: Durability and maintenance of concrete structures on Danish railways, by A. Jeppesen.

K2: Experiments on concrete bars; freezing and thawing tests, by E. Trudso.

General considerations of cracking in concrete masonry walls and means for minimizing it, by C. A. Menzel. Chicago, Portland Cement Association, 1958. (Development department bulletin D20)

A method for determining stresses in concrete reinforcement during long-time tests, by G. C. Rouse. Denver, U.S. Dept. of the Interior, Bureau of Reclamation, 1958. (Technical memorandum 655)

Rapid tests for aggregrate and concrete. Washington, Highway Research Board, 1958. (Bulletin No. 201)

Directories

The Engineer buyers guide, 1959 London, Morgan Bros., 1959.

Lindsay's international register of wire rod and strip, 1957-1958.; Wolverhampton, Eng., Lindsay's Wire Publications, 1958.

Electrical engineering

The electrical year book, 1959. Manchester, Emmott, 1959. 3 6.

A-C circuit analysis, ed. by A. Schure. New York, Rider, 1958. $1.80

Electrical Research Association: Tech-

• BRANCH NEWS

(Continued from page 123)

The Pembina Overpass is a four span structure founded on precast piles driven into hardpan. The superstructure is also a composite design.

The Red River Bridge is similar in design to the Assiniboine bridge. It is a seven span structure, 848 feet long with three river piers carried on spread footings resting on hardpan.

The last structure also under construction is known as the Gladstone Overhead. This structure was to be completed June 1959.

SAGUENAY

H. C. Perreault, JR.E.I.C., *Correspondent*

J. W. L. Duncan, project engineer, electrical, Aluminum Company of Canada Ltd., Arvida, spoke at the meeting of March 17 on the Chute-des-Passes project.

This was a general description of the project to its present state. Slides were used to show topography and the general dimensions of the intake section, supply tunnel, underground powerhouse and discharge tunnel. The electrical features, especially the generator governors and transmission line were described.

UNIVERSITY OF SHERBROOKE

Bernard Vigneux, S.E.I.C., *Correspondent*

The student section is now officially established, with officers as follows: president, Andre C. Hamel, vice-president, Marc Gagnon, secretary, Bernard Vigneux. There are 35 new members.

On the occasion of the Faculty's first Ritual of the Calling of an Engineer, the guests were Dr. K. F. Tupper, E.I.C. president and Dr. Garnet T. Page, general secretary. Twenty-two students received the engineer ring. The president took this opportunity to present the E.I.C. student prize to Gilles Henault.

Jacques Lemieux, director of studies, Science Faculty; Gilles Henault, winner of E.I.C. bursary; Gaetan Cote, vice-dean; and President K. F. Tupper.

Student Night was held on March 20, at which four students gave papers: Sounding by Helicopter, Robert Leblanc; Puits Filtrants, Yvon Nadeau; Effects of Electricity on the Human Body, Gilbert Luneau; Power Plant, Charles Lebreque.

The program during the year has included many films, a talk by Rev. Fr. Adelphe, M.S., titled, "Science". The program will be concluded with a formal dance to mark the first graduation of the Faculty of Engineering of the University of Sherbrooke.

UNIVERSITY OF WESTERN ONTARIO

Paul Ruppel, S.E.I.C., *Correspondent*

The first annual banquet of the Undergraduate Engineering Society was held on March 12, with 140 students and faculty members present.

Guest speaker was Harry Hallworth, treasurer and general manager of the copying productions division of Minnesota Mining and Manufacturing of Canada Ltd.

Prof. S. L. Lauchland, head of U.W.O. engineering science, was made an honorary member of the Society on this occasion. Another highlight was election of officers, as follows: chairman, Paul Vellinga, secretary, George Steele, treasurer, Jim Savage, publicity director, Paul Ruppel, sports director, Howard Kagawa, and director of professional relations, Bob Frank.

The graduation dinner was on March 26, 1959, when members of the graduating class heard guest speaker E. V. Buchanan predict tremendous advances in engineering in the next few years, and an expansion of engineering opportunity unparalleled in history.

• OTHER SOCIETIES

Calendar

United Nations Educational, Scientific and Cultural Organization: International Oceanographic Congress to be held in New York from August 31 to September 12, 1959.

UNESCO is cooperating with the sponsor, the American Association for the Advancement of Science (1515 Massachusetts Ave., N.W., Washington 5, D.C.)

International Association for Hydraulic Research: eighth congress, Montreal, to be held during the week of August 24, 1959.

Information from J. E. L. Roy, c/o Quebec Hydro-Electric Commission, 107 Craig St. W., Montreal 1, Que.

The Building Exhibition: The 1959 Building Exhibition, London, England, November 18 to December 2, 1959.

Steel Founders' Society of America: fifty-seventh fall meeting, The Homestead, Hot Springs, Va. September 21-22, 1959.

The National Society of Professional Engineers: annual meeting, Commodore Hotel, New York City, June 17-20, 1959.

Canadian Electrical Association: sixty-ninth annual convention, Manoir Richelieu, Murray Bay, Que., June 24-26, 1959.

American Welding Society, New York, N.Y.: fall meeting, Sheraton-Cadillac Hotel, Detroit, September 28-October 1, 1959.

Columbia University: Department of Industrial and Management Engineering announce the eighth utility management workshop, Arden House, July 26-August 7, 1959.

The Institute of Radio Engineers: fourth annual IRE Canadian convention and exposition, Automotive Building, Exhibition park, Toronto, October 7-9, 1959.

IRE convention offices are at 1819 Yonge St., Toronto.

Science Council of Japan: second world conference on earthquake engineering, Tokyo and Kyoto, Japan, July 11-18, 1960.

Information about the program, about participation and attendance is available from the Science Council, Ueno Park, Taito-ku, Tokyo, Japan.

Ontario Water Resources Commission: sixth industrial waste conference, Honey Harbour, Ontario, June 15-17, 1959.

American Meteorological Society: national meeting, San Diego, California, June 16-18, 1959.

International Council for Building Research: Congress 1959, will take place on September 21-25 in Rotterdam, The Netherlands.

Further information can be obtained from The Congress Secretariat c/o Bouwcentrum, Postbox 299, Rotterdam.

Canadian Red Cross Society: National Water Safety Week, June 14-21, 1959.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

The four page, 2-colour (black and blue) insert of the Northern Electric Company Limited in the March issue of this "Journal", pages 31-34, was judged the best from the view-points of Accuracy-Information-Attraction. The jury consisted of 50 subscribers; five from each province.

The advertisement was planned and produced by Foster Advertising Limited, Montreal. The artist is Maurice Picard, Montreal, and Northern Electric's advertising manager is E. H. Woodley.

The certificate was presented to Mr. Woodley, by the General Secretary, Garnet T. Page, at a luncheon at the Engineers' Club, Montreal. A copy of the certificate was presented to Mr. Frank B. Thompson of Foster Advertising Limited.

Readers' response to requests for their services as jurors is most encouraging. During the first four months of the year a monthly average of 42 (out of a total of 50) completed questionnaires have been received. This co-operation is greatly appreciated by the Institute and the advertisers. The results of the judgeing will provide industrial advertisers with a guide as to the type of advertisement which is the most useful and attractive to Canadian engineers.

NORTHERN ELECTRIC CO. LTD. WINNING INSERT

This illustration is a monotone reproduction of the 4-page insert which readers selected as the best advertisement in the March issue, from the view-points of Accuracy, Information and Attractiveness.

The advertisement appeared on page 31-34. The actual advertisement was printed on offset, dull finish, stock, in black and blue.

Front Back

Centre Spread

You *can have your accounting done for you* *on* IBM **ELECTRONIC COMPUTERS** *at the* **IBM** *Service Bureau*

IBM Data Centre, Don Mills Road, Toronto.

IBM Service Bureau prepares our insurance renewals and gets them out earlier than we can ourselves.

It's confidential! IBM does our accounting, and from experience we know they keep our records in strict confidence.

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• LIBRARY NOTES

(Continued from page 132)

***ENTWURF UND BERECHNUNG VON STAHLBAUTEN; VOL. I: GRUNDLAGEN DES STAHLBAUES**

The first volume of a series on the design and calculation of steel structures covers the following: steel as a building material; riveted, bolted, and welded connections; numerical solutions in statics; bending and torsion of beams; stability problems — buckling and collapsing; vibration; and the determination of optium dimensions and characteristics of structural elements. (F. Stussi. Berlin, Springer-Verlag, 1958. 577p., 55.50 DM.)

***THEORIE UND BERECHUNG DER STAHLBRUCKEN, 4TH ED.**

In dealing with the theory and design of steel bridges the author first discusses the fundamentals of elasticity and plasticity. He then develops the theory of plates and of girder grillages, and reviews the stability problem with special attention to buckling. The rest of the book is devoted to modern design methods for highway bridges, solid-web girder bridges, lattice girder bridges, arch bridges, suspension bridges, and compound bridges. The book is intended for the structural engineer as well as for the student. (A. Hawranek, rev. by O. Steinhardt. Berlin, Springer-Verlag, 1958. 426p., DM 66.)

***PLASTIC DESIGN OF STEEL FRAMES**

In addition to presenting simple plastic theory and methods of plastic analysis, such secondary design considerations as the influence of shear force, axial force, and buckling are reviewed. Using plastic analysis as a base, design procedures are given for proportioning building connections with particular reference to welded connections. A special feature is the chapter on "Design Guides" which provides in chart form the analysis and design procedures and the secondary design guides presented in this book. (L. S. Beedle. New York, Wiley, 1958. 406p., $13.00.)

MECHANICS: PART I: STATICS, 2ND ED.

Following an introduction to statics and dynamics, the resultants of force systems and the equilibrium of force systems are presented as are structures, distributed forces, and friction. A chapter is devoted to the principles of virtual work and shows the type of problems for which this method is superior. Full use of graphic procedures is made whenever they are of advantage, and problems are included which emphasize practical engineering situations. In this edition some of the chapters have been rewritten and many new problems have been added. (J. L. Meriam. New York, Wiley, 1959. 393p., $5.00.)

***ADVANCED MECHANICS OF FLUIDS**

An advanced sequel to the editor's earlier work, "Elementary Mechanics of Fluids". The goal of the present volume is the development of research methods, so that the theoretical approach is given primary emphasis. Among the topics discussed are irrotational flow, conformal representation of two-dimensional flow, laminar motion, turbulence, boundary layers, and free-turbulence shear flow. (H. Rouse, ed. New York, Wiley, 1959. 444p., $9.75.)

***HIGH TEMPERATURE WATER SYSTEMS**

Intended for engineers and contractors this volume contains data used successfully in high temperature water systems. Design, specification, installation, application, and economics are presented in detail. Specific aspects discussed are pressurizing, boilers and expansion tanks, system control, circulating pumps, valves, piping, and process and space heating. A feature is the complete treatment of the design of a typical system. (O. S. Lieberg. New York, Industrial Press, 1958. 211p., $7.75.)

***MECHANICAL PROPERITIES OF NON-METALLIC BRITTLE MATERIALS**

Papers which attempt to devise reliable methods of measuring the mechanical properties of non-metallic brittle materials, and to explain the reasons for their observed behavior. A variety of materials is studied such as coal, glass, rocks, ceramics, and concrete. Topics covered include strength in compression, tension, bending, and shear; elasticity and creep; dynamic loading, impact, and fragmentation; action of tools, with particular reference to coal. These papers constitute the proceedings of a conference held in London in 1958. (W. H. Walton, ed. Toronto, Butterworth, 1958. 492p., $12.75.)

***CONSTRUCTION MANAGEMENT AND SUPERINTENDENCE**

Examines the complex division of duties, responsibilities, and procedures among the owner, the architect, and the contractor. In part one the author covers the details of construction management. Using specific examples he deals with contracts and sub-contracts, changes of contracts, purchasing and deliveries, cost records, job office control, and the records necessary to keep track of hiring and discharging workers. Part two describes how to supervise each of thirteen trades to see that the plans and specifications are followed from start to finish. Included are subgrade work, concrete work, masonry, roofing, lathing and plastering, floor finishing, and painting. (W. C. Ross. Toronto, Van Nostrand, 1958. 238p., $8.25.)

***THE PETROLEUM CHEMICAL INDUSTRY 2ND ED.**

A description of the major products and the basic chemistry of the processes used, along with an indication of their commercial possibilities. New chapters have been included on the history of the petroleum chemicals industry and on statistics and economics, while many of the chapters have been enlarged and rewritten. (R. F. Goldstein. Toronto, McClelland and Stewart, 1958. 458p., $20.00.)

***DYNAMICS OF FLIGHT: STABILITY AND CONTROL**

The underlying principles and techniques of the dynamics of flight are presented. Incorporating recent developments, the author covers static and dynamic stability, transient and frequency response, feedback systems and automatic controls, dynamics of missiles, machine computation, and mathematical aids. In addition material on inverse problems and on flight through turbulent air is included. Automatic control theory is approached from the aeronautical engineer's viewpoint, while machine computation is approached from the standpoint of the machine user rather than the computing specialist. (B. Etkin. New York, Wiley, 1959. 519p., $15.00.)

***MANUAL OF STRUCTURAL DESIGN, 4TH ED.**

A manual providing a wide variety of tables and methods of calculation used in structural design. This edition contains entirely new information on concrete joists, slabs, flat slabs, stirrups, concrete columns, footings, and retaining walls. The steel beam tables are entirely revised and new tables have been added on long span joist, compound sections, and fireproofing. (J. Singleton. Topeka, Ives, 1957. 272p.)

***BASIC GEOLOGY FOR SCIENCE AND ENGINEERING**

A systematic development of physical geology with particular emphasis on those principles suitable for engineering application. Among the topics discussed are soil materials, physical and chemical properties of rock materials, soil forming processes, streams, shoreline processes, ground water, wind deposits, and crustal deformation. A considerable number of tables and graphs have been included. (E. C. Dapples. New York, Wiley, 1959. 609p., $9.50.)

***COMPACT HEAT EXCHANGERS**

A comprehensive treatment of compact heat transfer surfaces, including tube banks, plate fin surfaces, finned tube surfaces, and screen and sphere matrix surfaces. Analytical solutions are considered for abrupt contraction and expansion pressure-loss coefficients, laminar-flow heat transfer in circular and rectangular tubes, and the effects of temperature-dependent field properties on heat transfer and flow friction. A chapter is devoted to heat-exchanger performance theory, developed around the effectiveness versus number of heat-transfer units. Use of the data and theory is illustrated by sample problems. (W. M. Kays and A. L. London. Toronto, McGraw-Hill, 1958. 156p., $6.90.)

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

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JULY 1959
vol. 42 no. 7

Cables: Enginst-Montreal
PRINTED IN TORONTO
ice $6.00 a year in Canada, British Posses-
ons, United States and Mexico, $7.50 a year
Foreign Countries. Current issues, 75 cents
copy, back issues from $1.00 per copy up.
members and affiliates, 50 cents a copy,
.00 a year.—Authorized as second class mail,
st Office Department, Ottawa.

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The Applied Science and Technology Index
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(19,900 copies of this issue printed)

MEET THE AUTHORS

The late Sir Claude Gibb, KBE, FRS, Hon. M.E.I.C., chairman and managing director, C. A. Parsons and Company Limited, Newcastle-upon-Tyne, England. (*Graphite in the World Nuclear Power Program*).

Born in Adelaide, Australia, Sir Claude Gibb graduated from the South Australian School of Mines (Adelaide University) and later did post-graduate study at London and Durham Universities to obtain his doctor's degree. In the first World War he was a pilot in the Australian Flying Corps and in the Second World War he was Director General, Armoured Fighting Vehicles and chairman of the British Tank Board.

He started his industrial training as a fitter at the Heaton Works of C. A. Parsons and Company Limited, rising rapidly to chairman and managing director, which position he held at the time of his death.

In 1945 he was honored by the King with a knighthood for his war work and in 1956 was made Knight of the British Empire for his outstanding contribution to the development of atomic power.

We are indebted to **Mr. H. B. Topham**, director and general manager of the Anglo Great Lakes Corporation Limited, for preparing this paper for publication in *The Engineering Journal*. Mr. Topham was personal technical assistant to the late Sir Claude Gibb for twenty years.

N. W. Radforth, professor of botany, McMaster University, and **Jean Margaret Evel**, organic terrain studies, National Research Council and Defence Research Board (*Mobility on the Muskeg Frontiers*).

Mr. Radforth was born in England and emigrated to Canada in 1920. He graduated from the University of Toronto in Honour Biology in 1936 and began teaching in that university in 1939. In 1946 Mr. Radforth was appointed as head of the department of botany, McMaster University and became the first director of the Royal Botanical Gardens, Hamilton. Recently he was awarded a Royal Society of Arts (London) silver medal for a paper on peat in Canada and Britain and its economic implications.

Jean M. Evel

Miss Evel was born in Hamilton, Ontario and received a B.A. from McMaster University in 1948 in botany and zoology.

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Mr. Blue graduated from the University of Toronto in 1921 with B.Sc. joining the Manitoba Hydro-Electric Board in 1956 after many years of experience with other firms.

Mr. Scott graduated from the University of Manitoba in 1946 with B.Sc. in electrical engineering. He served three years as chief, electrical section, engineering and construction division before being appointed assistant manager of the division in 1959. He has served also as chairman of the electrical section of the Winnipeg branch of the Engineering Institute of Canada.

P. A. Pasquet, M.E.I.C., chief project engineer, thermal division, A. C. Shamess, M.E.I.C., director of Electrical engineering and **W. P. London**, M.E.I.C. chief engineer, thermal division, all of H. G. Acres & Company Limited (*Special Features of the Brandon Generating Station*).

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J. B. Bryce, M.E.I.C., Hydraulic engineer, Hydro-Electric Power Commission of Ontario, (*Head-Loss Coefficients for Niagara Water Supply Tunnels*).

Mr. Bryce graduated from the University of Toronto in civil engineering in 1935 and obtained his M.A.Sc. degree in hydraulic engineering in 1936. After graduation he joined the Ontario Hydro and became hydraulic engineer in 1953. From 1938-40 Mr. Bryce was with the National Research Council's hydraulic laboratory. He also serves on International St. Lawrence River Board of Control.

(At time of going to press no information was available on Mr. R. A. Walker, the co-author of this paper).

A. M. Lount, M.E.I.C., consulting engineer, A. M. Lount and Associates (*The Use of Electronic Computers in the Field of Civil and Structural Engineering*).

Mr. Lount graduated from the University of Toronto in 1946 with a B.Sc. in civil engineering. He worked seven years for Ontario Hydro Commission and with the engineering division of Pre-Stressed Concrete. He formed partnership with Dr. Lazarides in 1953 and in May 1957 formed his own firm, A. M. Lount and Associates.

T. Blench, M.E.I.C., professor of civil engineering University of Alberta (*River Engineering as a College Course for Civil Engineers*).

Professor Blench received his B.Sc. with 1st Class Honours in civil Engineering and mechanics from the University of Glasgow, 1927.

With Irrigation Branch, Public Works Department, Punjab, India, 1927-48 Professor Blench became director of irrigation research. He served in India from 1942-45 being in charge of Air Force Works Research and Development Section. In 1948 he joined University of Alberta staff, and also carries on a consulting practice.

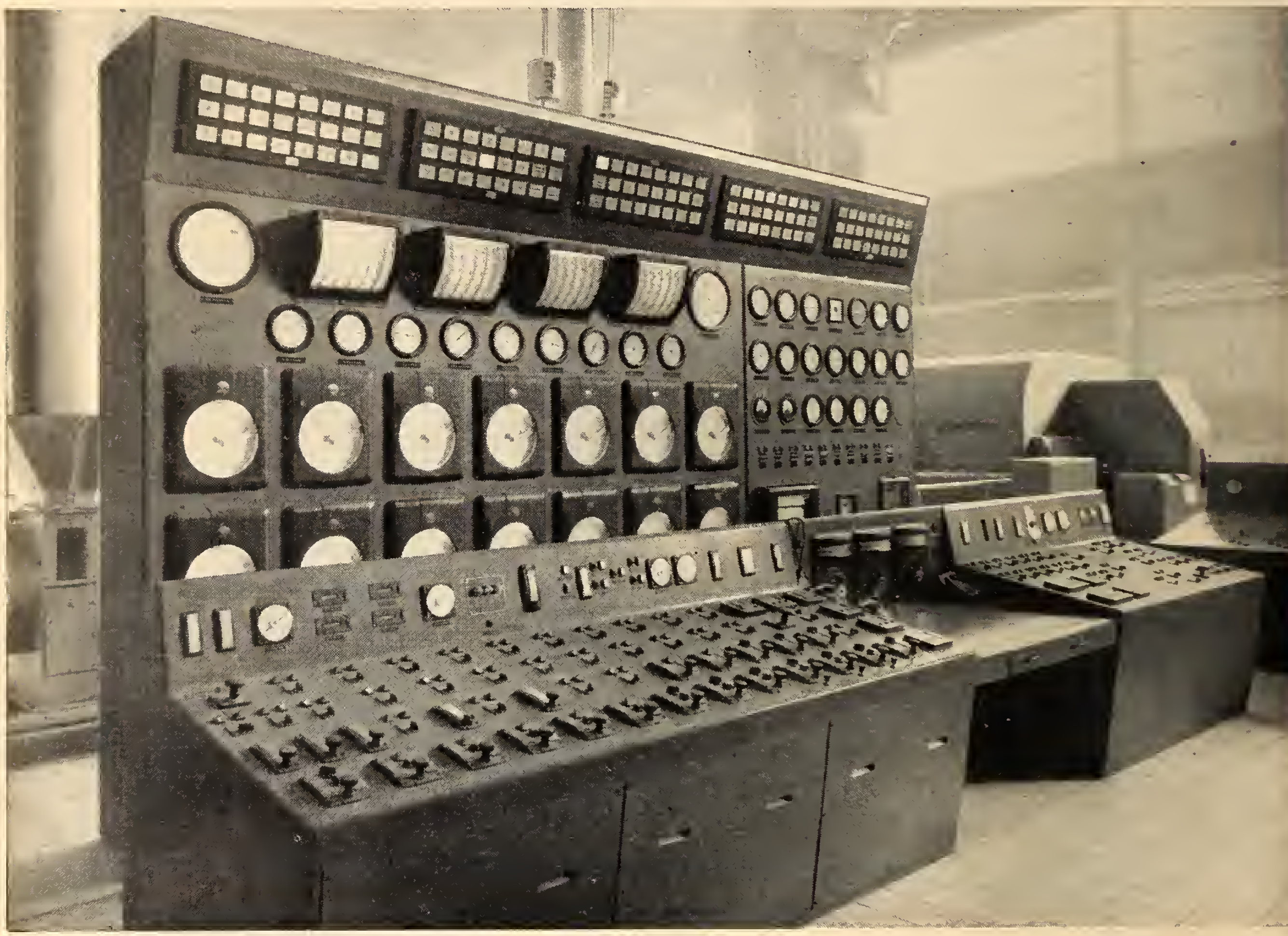
R. L. Duke, section engineer, mill industries, and **L. R. Hulls**, application engineer, Canadian Westinghouse Company Limited (*Magnetic Amplifier Control for Reversing Hot Mill Auxiliaries*).

Mr. Duke was born and educated in Vancouver, graduating from the University of British Columbia with B.A.Sc. in electrical engineering in 1941. He worked as an engineering apprentice for Canadian Westinghouse Company Limited and in 1943 became a section engineer.

L. R. Hulls, was born in Britain, graduated from Manchester University in 1943 in physics and electrical engineering. On graduation he worked with Signals Research Development Establishment until in 1949 he became chief of industrial electronic section at English Electric Company. He has held his present position since 1955.

BAILEY at Queen Elizabeth Power Station

Saskatchewan Power Corporation, Saskatoon, Sask.



Bailey vertical panelboard and miniaturized control console (foreground) comprise the "brain centre" of the boiler plant.

At the Saskatchewan Power Corporation's Queen Elizabeth Power Station, Bailey Meter Company Limited was selected to supply the following equipment.

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GRAPHITE IN THE WORLD NUCLEAR POWER PROGRAM

The late Sir Claude Dixon Gibb, K.B.E., FRS, HON. M.E.I.C.

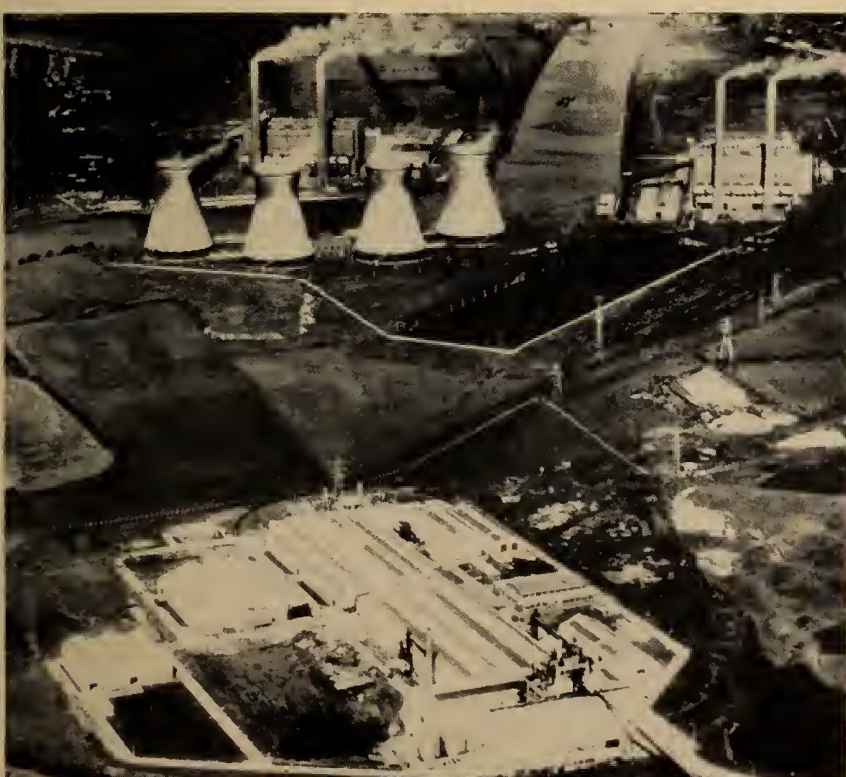
Chairman and Managing Director,
C. A. Parsons and Company Limited,
Newcastle-upon-Tyne, England.

The following paper was in an advanced stage of preparation by the late Sir Claude Gibb at the time of his death on January 15, 1959. He was writing it for presentation at the 1959 Annual General and Technical Meeting of the Engineering Institute of Canada.

Through the kindness of Mr. H. B. Topham, a colleague of the late Sir Claude for more than twenty years, the paper was completed and presented as scheduled at the 1959 Annual Meeting.

The Engineering Journal is privileged to bring to its readers this paper, by one of the world's most distinguished engineers.

Fig. 1. Aerial view of graphite plant including Stella North and South power stations.



A MERE ELEVEN YEARS separated the terror of Hiroshima and the potential blessing that Calder Hall offered to the world.

Devastation in 1945 demonstrated the power of the atom. That power is now tamed and turned to the benefit of mankind. The heat generated when fission takes place in an atom has been controlled and means found to extract, and then use it to raise steam for driving turbo generators for the production of electricity.

Almost every schoolboy today knows that one in every 140 parts of uranium metal is the isotope U_{235}, the remainder being U_{238}. The U_{235} atom is capable of splitting and in so doing a neutron detaches itself and, if it hits in its path another U_{235} atom, a further fission occurs releasing two neutrons which, under controlled conditions, can create further fission, each time creating energy which appears in the form of heat.

If the neutron from the U_{235} atom hits a U_{238} atom, then a new substance U_{239} can be formed called Plutonium which in itself is fissile, i.e. is capable of splitting and releasing one or more neutrons which thus could maintain the chain reaction or continuous controlled fission.

If uranium be specially prepared so that it consists wholly of the fissile isotope U_{235} there would be so many neutrons available to generate heat that only minute quantities could be arranged together, or else the rate of the chain reaction would release so much energy as to create a bomb effect. Natural uranium metal with only one part in 140 being fissile is entirely harmless and safe and can be handled in large quantities without fear of any bomb effect developing. Wholly enriched uranium is extremely dangerous, while in between those two extremes there can be an almost infinite range of enrichment from the entirely safe to the very dangerous.

Enrichment

Enrichment is uranium which has had the percentage of the fissile isotope U_{235} artificially increased by man. This can be done in several ways, e.g. by ultra high speed centrifuging whereby the non-fissile heavier isotope U_{238} is separated from its lighter but fissile companion U_{235}. But the method almost universally used is to prepare uranium hexafluoride which becomes a gas at a moderately high temperature which then is pumped through successive stages or cells where the inlet and outlet to the cell are separated by a porous membrane which allows the lighter U_{235} isotope to diffuse through at a faster rate than the heavier U_{238} and by doing this in series a great many times, eventually it is possible to produce material that is almost entirely U_{235} and therefore wholly fissile. Such material is extremely expensive, being costed at so much per gram, because of the high capital cost of the plant required and the huge quantities of electricity consumed in driving the compressors to maintain the uranium hexafluoride gas in the circuits.

It will be evident to engineers who, quite early, learned in life that "you can't get 'owt for nowt" that if you start with 140 pounds of natural uranium which would contain about one pound of the fissile isotope U_{235}, and, after passing this through the enrichment plant, you finish up with one pound of U_{235} separated from, instead of mixed with, the non-fissile and powerwise almost useless U_{238}, the amount of potential energy available is precisely the same except that that potential energy now weighs one pound instead of 140 pounds. But a very large amount of energy in the form of electricity has been used to concentrate the potential energy in the uranium.

Fig. 2. Unloading of coaster at quayside.

More Potential Power

The advantage of enriched uranium, — even if it is only slightly enriched, — is that more neutrons and therefore more potential power can be contained in a given volume. If, for example, with natural, i.e. non-enriched uranium, an output of 200 M.W. electrical can be obtained from a reactor core say 40 feet in diameter, then an output at least double that should be possible from the same core if instead of 0.07% of U_{235} in the fuel we could enrich 0.14%, i.e. double the amount of the fissile isotope. That reactor core has to be surrounded by a biological shield of the equivalent neutron absorbing capacity of say 9 feet thick of concrete. Hence the use of enriched fuel (uranium) enables a greatly increased output to be obtained from a given quantity of shielding concrete and a reduction in the cost of other equipment.

Fig. 3. Silos.

Cost Analysis

It will be obvious that if the cost of the electricity used in the enriching process plus the capital charges of the necessary plant exceeds the saving in capital charges due to reductions in construction size and costs of the enriched fuel reactor, then there is little or no advantage in enrichment. Only if electricity costs are extremely low and the enrichment plant has a very large throughput is it likely that a nuclear power plant using enriched fuel could compete economically with an indigenous fuel in most countries.

An inherent disadvantage of a natural uranium fuelled reactor is that the number of neutrons available for fission per pound or per ton of uranium are so few that neutron economy is of the utmost importance, but also, the minimum quantity of uranium necessary to maintain the essential chain reaction is quite large and such a reactor becomes increasingly economic as its output increases.

There is a minimum output below which the reactor cannot function and for very small outputs enriched fuel is essential.

Heavy Water

When fission occurs, the neutrons travel at great speed, exceeding the speed of light in fact, and to increase the chances of the neutrons splitting another fissile atom they must be slowed down by what is called a moderator. There are several moderators, the most efficient being heavy water since the number of neutrons captured by heavy water is the smallest of known moderators and therefore the all important neutron economy is a maximum. The whole of the Canadian research and development effort into efficient nuclear power production is based upon the use of heavy water as the moderator.

Beryllium or beryllia (the oxide) is another good moderator but is expensive and in short supply as well as being somewhat difficult to handle because of possible toxic effects.

Hydro carbons of the benzene ring family such as diphenyl or terphenyl are known as organic moderators and although suspect for a long time because of their known polymerisation under irradiation, it is now known that this effect is not necessarily so serious as to preclude their use. Active research is proceeding into the use of organic moderators but it seems likely that their use in a reactor would introduce complications which would appear to be undesirable.

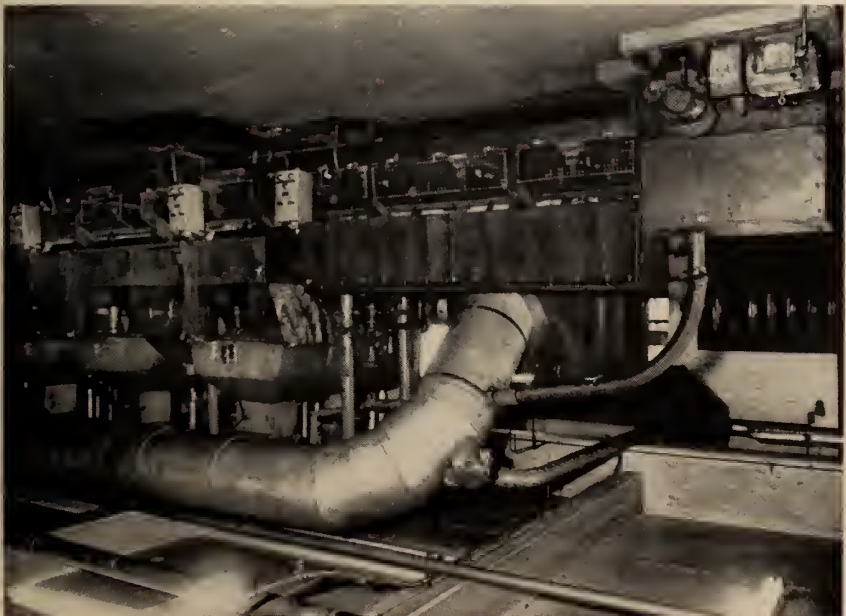
Demineralised light water is another possible moderator but with this the neutron capture is so high as to require the use of enriched fuel.

Fig. 4. Batch Weighing Control Board.

Graphite

Still another choice as a moderator is the carbon atom in the form of high purity graphite. Graphite as a moderator has advantages and disadvantages. Its disadvantage is that it captures many more neutrons than heavy water or diphenyl although less than light water. Its advantages are that it has considerable strength as a structural material even at very high temperatures and that it is relatively low in cost. Heavy water costs some $70,000 per ton against about $1,800 per ton for graphite machined to the shapes and sizes required for a reactor. But the weight of heavy water required purely as a moderator for a given electrical output is so much less than the weight of graphite that the moderator total cost with heavy water may not be that much above graphite as to be at least balanced by the greater neutron economy achieved. With heavy water the minimum output of a reactor fuelled with natural uranium is appreciably lower than with graphite.

Fig. 5. Batch Mixers.



When, in Britain, in 1948, the feasibility study that led to Calder Hall was begun, it was realised that the highest neutron economy would be achieved by using heavy water as the moderator. The only available source of heavy water at that time was the United States of America although small supplies were being produced at Trail, B.C., and in Norway.

Availability of both heavy water and dollars at that time had to be weighed against the disadvantages of graphite. Beryllium was not available; diphenyl was suspect, and light water demanded enriched fuel which was not available. The decision was taken to adopt graphite as the moderator for Calder Hall, and although tenders were invited for three fully commercial nuclear stations in Britain before Calder went critical or was known to be a success, those further designs were also to be graphite moderated.

The urgent need for Britain to find a fuel supplementary to coal or oil was and is so great that with enriched fuel unavailable and heavy water too costly in dollars to be considered, the nuclear power program had perforce to be based upon graphite and natural uranium.

Sixteen Reactors

Under construction in Britain today are sixteen graphite moderated reactors, eight at Calder Hall and Chapel Cross optimised for the production of plutonium with electricity as a by-product and two each at Berkeley, Bradwell, Hunterston and Hinkley Point, the latter eight being optimised for electricity production with plutonium as a by-product. The total electrical output of the sixteen reactors is 1,680 mw. nett. The cost of the nuclear power stations already on-load or under construction exceeds $600 million and is an indication of the faith we have in Britain in the graphite moderated type of reactor.

Reactor designers and research workers in Britain, however, are by no means neglecting the possibilities of the heavy water or organic moderated reactors for both small and large outputs of electrical power. For small outputs of say 20 to 30 mw. where natural uranium, graphite moderated reactors are both uneconomic and unsuitable, the heavy water moderated gas-cooled reactor is regarded as extremely promising.

But the potential of the graphite moderated gas-cooled reactor for large outputs is so great that attention in Britain is being devoted largely to their future development particularly in ways to further reduce capital costs which form such a large part of total generating costs.

GRAPHITE PRODUCTION

Only graphite of the highest possible purity is suitable as a moderator. Minute traces of boron for instance would so increase neutron capture as seriously to impair neutron economy and lead to an increase in reactor core size and the amount of uranium fuel charge. The maximum neutron cross section capture which can be tolerated is 4.0 millibarns but a figure as low as 3.75 can be obtained regularly if the utmost (and expensive) precautions are taken in the selection, transport and processing of the raw materials.

The moderating or slowing down of fast neutrons is a function of the mass of the graphite. Hence a greater volume of low density graphite is required than for high density material and thus maximum density is required to reduce the overall reactor core dimensions and thereby reduce capital costs. A minimum density of 1.70 is specified for British 'A' grade graphite but in fact an average density of 1.75 is achieved in large scale production while 1.78 to 1.80 can be reached by adding an extra impregnating and baking operation. It is however a question of economic balance between the saving in overall reactor costs excluding graphite and the additional cost of increasing the density.

Structural Strength

Graphite, as engineers generally think of it, in the natural or flaked form when used as a semi-dry lubricant, is useless for a reactor moderator. A graphite reactor core for an output of say 250 mw. electrical will be some 45 ft. in diameter and over 30 ft. high. It will be built up from bricks approximately 8 in. square by 30 to 36 in. long. And it will operate at a temperature approaching 1000°F. in the centre of the core. Hence considerable structural strength is necessary.

The three essentials therefore for reactor quality graphite are:—

a) Highest possible purity.
b) Maximum density that is economic.
c) Adequate structural properties.

The requisite physical properties can only be obtained by employing a structure which is interlocking and not laminar as is flaked or natural graphite. Furthermore, natural graphite as mined has so many impurities as to be useless without very expensive separation operations.

The graphite used in reactors is a

Fig. 6. Cooler in Mill Building.

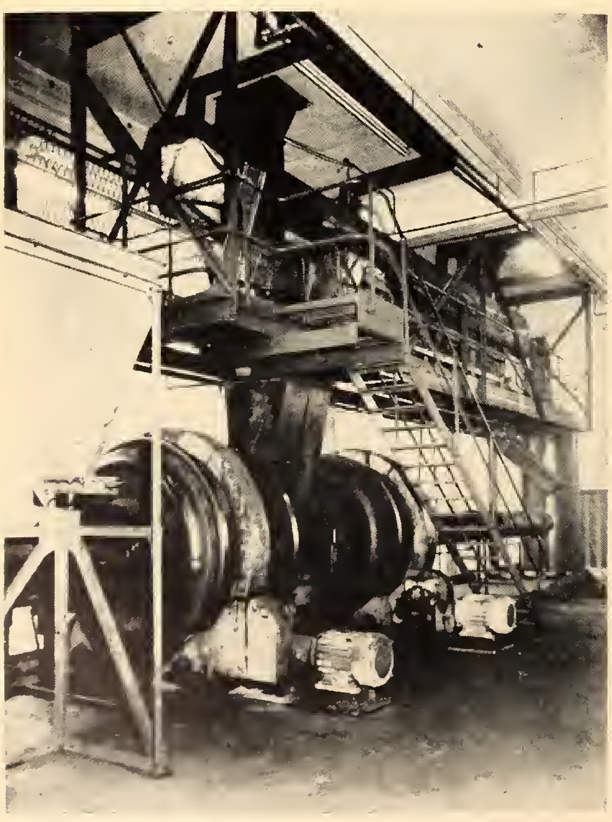
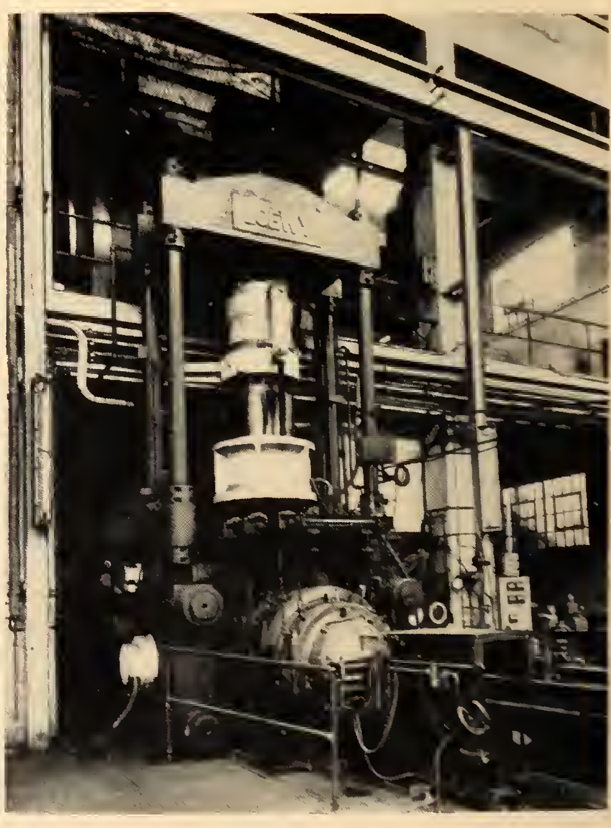


Fig. 7. Extrusion Press.



synthetic type, produced from high purity petroleum coke and equally high purity low ash coal based binder pitch. The transition stages from these raw materials to the finished product call for considerable science in selection, grading and control, but at least an equal amount of art in the shape of extensive manufacturing experience.

When the British Government in 1956, announced their extended nuclear power programme based upon graphite moderated gas-cooled reactors, there was only one source of supply in Britain for reactor quality graphite and this source was inadequate to meet the quantities which would be required. The United Kingdom Atomic Energy Authority decided to extend the factory of the existing producer and to provide an alternative supply source.

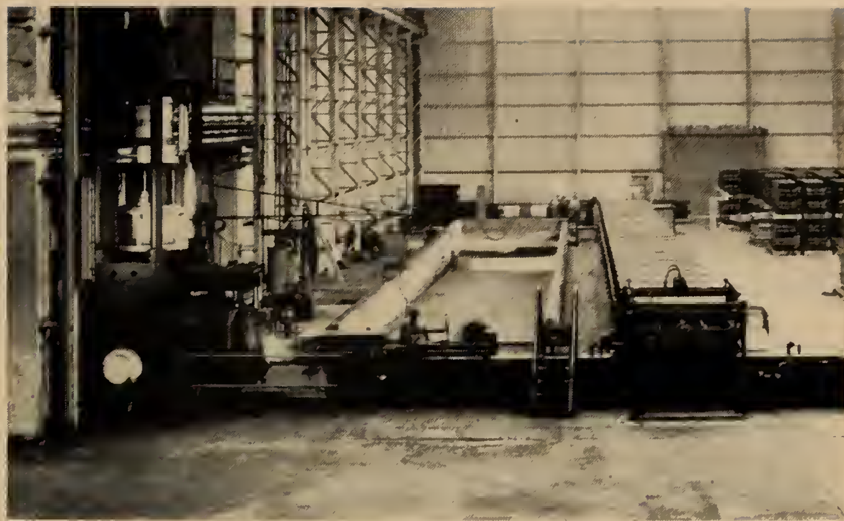


Fig. 8. Extrusion Bay.

New Factory

The description which follows is of the new factory built as the alternative supplier.

It will be obvious that *The Nuclear Power Plant Co. Ltd.*, a consortium of eight companies especially experienced in one or other portions of a complete nuclear power station, had a special interest in the availability and quality of the graphite required for reactor cores. Hence four of those eight member companies agreed to provide staff and much of the finance necessary to construct and operate a graphite factory, but, to buy time because speed in getting into production was essential, they would need technical assistance in design and early operation.

The Great Lakes Carbon Corporation of U.S.A. had graphite factories at Niagara Falls, New York State, and at Morganton, North Carolina and, although these factories produced commercial grade graphite, they had prepared limited quantities of reactor quality material. *The Great Lakes Carbon Corporation* had, during 1955, considered the possibility of building a graphite factory in Europe to meet a market there for electric steel furnace electrodes and other commercial graphite demands. Discussions between the interested British companies and the *Great Lakes'* executives indicated the likelihood of reaching agreement speedily on a basis for cooperation in design, construction and operation.

When producing nuclear graphite to a very rigid specification it was obvious that some rejected material would arise. Additionally, some of the high purity coke used as packing material during the baking cycle in producing artificial graphite can only be used once in case it receives any contamination, yet that packing coke may well be suitable as raw material for producing commercial grade graphite. So also would be rejected nuclear graphite. Hence the decision was taken to consider the economics of a factory capable of producing 10,000 long tons a year of nuclear graphite plus 5,000 tons a year of commercial grade graphite.

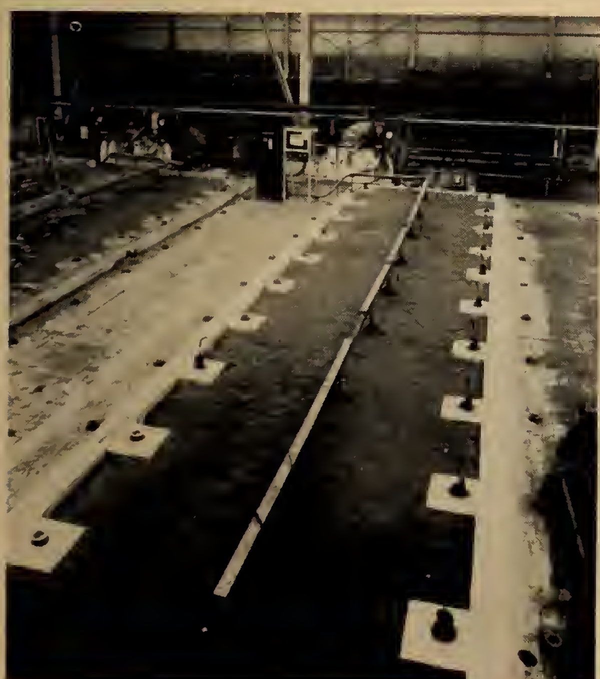


Fig. 9. Baking Furnaces

New Company

The economic study made showed that such a factory was just about the minimum output that would be competitive, and agreement was reached between the U.K.A.E.A.; the *Great Lakes Carbon Corporation* and the four British firms to proceed at once. A new British company was formed called *Anglo Great Lakes Corporation Ltd.*, and construction began in February, 1957.

The selection of a suitable site was extremely difficult. Since no petroleum coke is produced in Britain, that major raw material would have to be imported and hence sea or river access was desirable to reduce handling costs. Much of the finished product would have to be delivered long distances and therefore rail access was desirable.

Large quantities of electrical power would be used at a very high annual load factor, but with considerable phase unbalance at frequent intervals

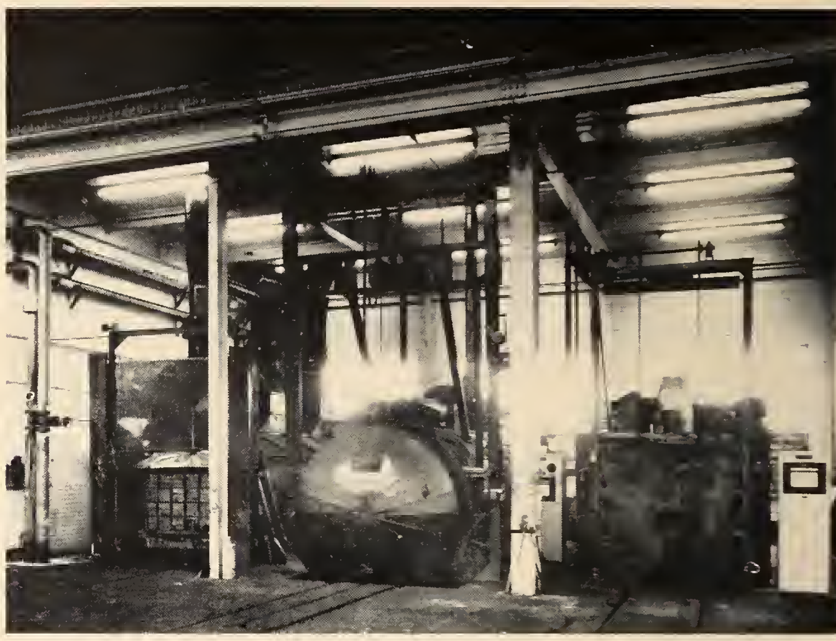


Fig. 10. Impregnators

because the graphitising furnaces are each single phase. Finally, the factory emits some smoke with pitch fumes and thus should not create a nuisance to a residential area. On the other hand, a staff of over 300 would be required and these must not have too far to travel.

Newburn Haugh

The only site fulfilling all these requirements was adjoining the Stella North generating station of the Central Electricity Generating Board and had been reserved by them for possible extensions. Since, however, the majority of the nuclear graphite to be produced would be used in the Generating Board nuclear power stations, they agreed to release the site for the erection of the graphite factory. Fig. 1. shows an aerial view of the completed plant at Newburn Haugh, some five miles west of Newcastle upon Tyne, with Stella North generating station and its four cooling towers on the north side of the River Tyne and Stella South generating station on the south or left bank of the river. Stella North has four 60 mw. turbo generators and Stella South five 60 mw. units. The two stations are interlinked at 132 kv. and are connected to the 275 kv. super grid running north to Scotland and south to Yorkshire. Hence a double circuit 132 kv. connection direct from Stella North, a matter of only 1,000 yards provides adequate safeguards for continuity of supply to the graphite factory which is important.

RAW MATERIALS

The petroleum coke is received in bulk by sea and unloaded by a grab mounted on a dockside crane. Fig. 2. shows a Dutch coaster being unloaded at the wharf of the *Anglo Great Lakes Corporation*. The grab delivers the coke into a hopper attached to the crane and travelling with it, and, by an electric vibrator, is passed to conveyor belts which take it to the primary crusher and thence by a third conveyor to the top of ten reinforced concrete storage silos, Fig. 3. where a cross conveyor delivers to the silo selected. Continuous sampling is done at this point.

The binder pitch at present is delivered by rail but consideration is being given to the possibility of delivering it in bulk by a coaster to the coke wharf. At all stages in the design of the factory, the truism that "handling adds nothing to the value of the product but does add to the cost" was always in mind and bulk handling of the pitch is a potential means of reducing manufacturing costs.

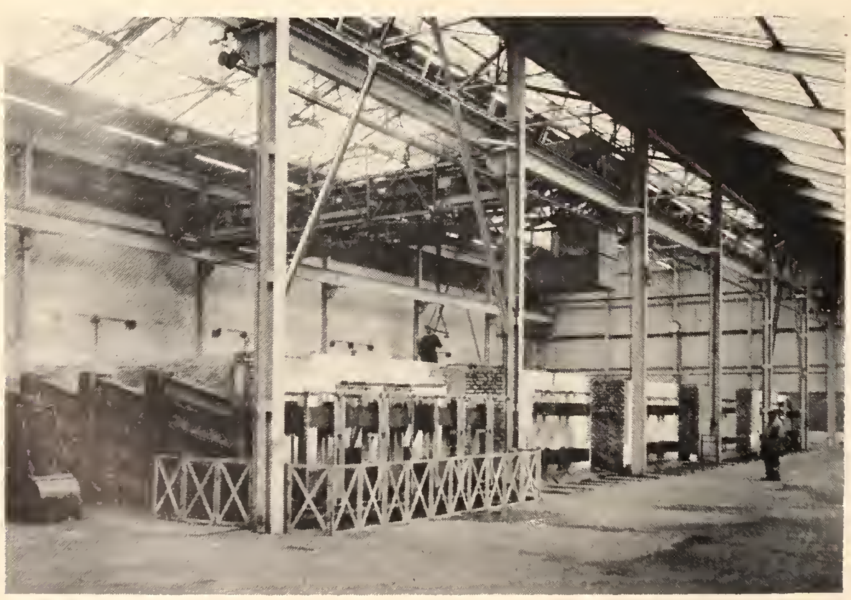
The relatively low melting point impregnating pitch is delivered in sealed containers by road.

THE PROCESSES

The petroleum coke after going through the primary crushers en route to the silos is drawn from the bottom of the appropriate silo and part of it is crushed before being sized on vibrating screens. The remainder is passed by chute to a Raymond type pulverising mill, to be reduced to flour size and conveyed to one of a series of bins each containing one of a range of particle sizes.

Depending on the density required and the duty for which the graphite is needed, the quantity of each particle size range is selected by the Technical Superintendent by a combination of science and art. Long experience has shown that there is a considerable scale effect between laboratory or pilot plant results and full scale production tests. Although high quality scientists are employed in the research laboratories both for quality control of raw materials and of finished product and for continual research into improved techniques, there is always the necessity for the production man to make adjustments

Fig. 11. Graphitising Furnaces.



in manufacturing techniques based upon a long experience. There is no direct road from laboratory to full scale operation.

The binder pitch similarly is prepared by crushing but as the pitch must be thoroughly mixed with the coke and, in effect, wet the coke, the pitch is crushed to a fairly uniform fineness yet larger than powder to assist handling.

Electro Pneumatic System

At the *Anglo Great Lakes* plant, the weight of each particle size and the weight of binder pitch having been selected, the actual weighing and distribution to the next process is done automatically by an electro-pneumatic system. The control board for this is shown in Fig. 4. Considerable difficulty was experienced in securing uniform and accurate batch weights at start-up due to the choking of filters with coke flour, i.e. coke passing through a 200 mesh sieve. Changing the type of filter and increasing their size was most effective and the amount of material lost in batch weighing is about one half of one percent and appreciably less than occurs when scale car weighing.

Each batch of coke and pitch after weighing is delivered to a heated mixer where the temperature is raised sufficiently to ensure the coating of each coke particle with pitch and a thorough mixing. Fig. 5. shows a part of the two rows of mixers.

The mixers discharge onto a band conveyor at a temperature which gives the batch a consistency rather like very stiff putty. Were it extruded to shape at this temperature, damage and deformation in handling would occur. The "mix" is therefore passed through a cooling mill, Fig. 6. and, at the appropriate temperature, loaded into the extrusion press, shown in Fig. 7. Temperature and consistency control at this stage is of great importance with experience playing a much bigger part than science. No one temperature will give satisfactory results in shape maintenance over varying cross sections.

The extrusion press drum is trunion-mounted so that it may rotate into three positions. Midway between vertical and horizontal it receives the charge of the mixture from the cooling mill. Next, in the upright position, a tamping ram consolidates the mixture and finally, in the horizontal position, the main ram extrudes the material through an electrically-heated die. The press is equipped with interchangeable reducers, so that a full range of dies may be used to produce either square bricks of nuclear graphite or cylindrical electrodes for steel furnaces.

Fig. 12. Power Transformers.

Green Stock

The extruded material as it leaves the die is of "cheese-like" consistency, which may be cut to required lengths by travelling shears before being transferred to a cooling belt. When cold the material, now known as green stock, is closely examined to make sure that its density, resistivity and general physical properties are up to specification.

Exceptionally fast steel works' cranes, arranged at two levels, are used to transfer batches of the green stock from the extrusion bay, shown in Fig. 8. to the baking bays, Fig. 9. where it is then loaded into muffle type furnaces for baking at about 1,000°C.

In the baking process the binding pitch in the green stock loses its volatiles and is reduced to coke. For this operation the bricks are loaded vertically into the baking furnaces and to prevent distortion and assist conduction of heat they are packed tightly with petroleum coke. The heating and cooling cycle in the baking furnaces takes about two weeks.

Baked stock is lifted out of the baking furnaces before it is cold onto a cooling belt at the end of which is a wire brushing machine to remove any loose packing material adhering to the surface. A further close inspection is then made to check density, resistivity and any visible signs of cracks or distortions.

The density of the material may then be increased, if required, by impregnating with a petroleum pitch. Fig. 10 shows a vacuum pressure impregnator designed to reduce the air pressure to within one or two millimeters from perfect, and shows that the baked stock, which has been heated to over 200°C. enables the pitch to penetrate fully into any voids caused during the previous baking process. Whilst immersed in pitch the vessel is subjected to a pressure of over 100 lbs. per square inch.

To obtain higher density for nuclear graphite it may be given further baking and impregnating treatment, though with diminishing returns for each successive cycle.

Furnaces

The last operation is to change the amorphous carbon sections into crystalline graphite by heating it to a temperature of at least 2,800°C. in a muffle furnace. The stock is mechanically handled from the baking bay into the graphitising bays where it is placed into one of thirty electric resistance furnaces, a group of which may be seen in Fig. 11. The furnaces are arranged on each side of heavy busbars to which they may be connected by specially designed switches mounted on cranes which traverse pressurised busbar chambers. Graphite furnace transformers feeding the busbars, which are single phase, are carefully controlled to take a balanced load from duplicate 132 kv. power lines supplying two power transformers, Fig. 12.

A special feature in the production of nuclear graphite is the maintenance of exceptionally clean conditions at all stages of manufacture and in maintaining the freedom from contamination, which is the prime concern in the selection of raw materials. Efficient dust control is maintained together with regular vacuum cleaning of the entire factory. The contamination, which could be picked-up from handling equipment, furnaces and

(continued on page 53)

MOBILITY on the MUSKEG FRONTIERS

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THERE ARE SIGNS — fixed and commanding — that exploitation of the petroleum potential of northern North America may either end abruptly or plunge the oil industry into a type of financing that contemporary economics will label prohibitive. The reason? Muskeg, better designated Organic Terrain. On the present frontiers of exploration in the northlands, this type of terrain is no longer a new acquaintance and indeed no longer casually impedes. There are few places where it does not present a barrier to operations. To surmount this barrier imaginative engineering skill has been combined with two new studies — Terradynamics and Palaeovegetography.

Imagine extensive beds of peat frequently heavily charged with water as liquid or ice. If this is conceived as covered above by special but varied vegetation and below by mineral soils differing as to properties, and the whole complex characterized by special physiographic circumstances—then the meaning of Muskeg will be basically understood. It follows naturally that Muskeg is best described as Organic Terrain.

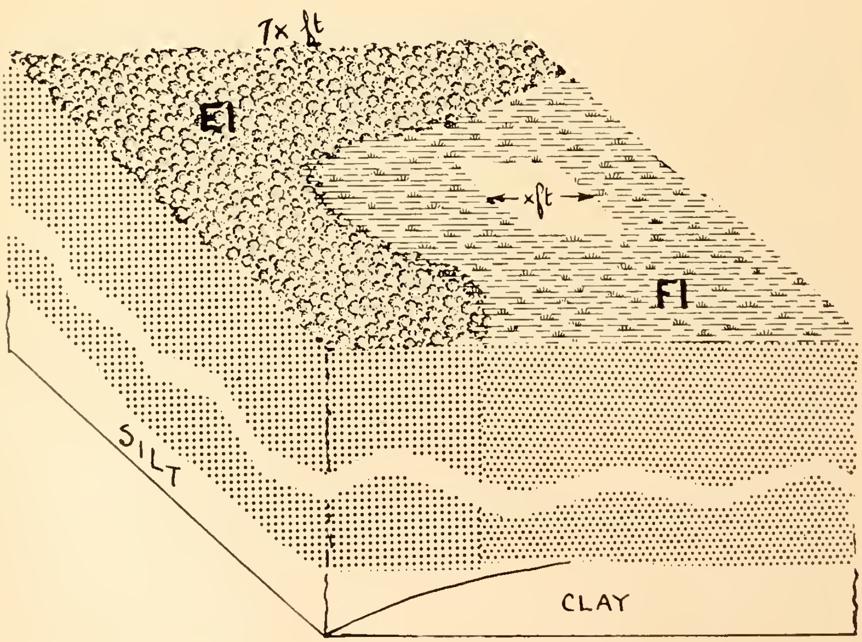
The interpretation of the history and structure of the ancient (fossilized) vegetation, the predominating component of the terrain contributing to the peat, is known as Palaeovegetography. It is a new study which probably would never have arisen had it not been for the fact that Organic Terrain exhibits a wide range of difference.

It is these differences that have precipitated the other new discipline known as Terradynamics,[1] the study of accessibility over organic terrain and the design of new vehicles pertinent to this study.

When considered in the light of research, organic terrain has not revealed itself as a disorderly medium, problematical though it has proved to be. Identification of its most frequently encountered types is dependent on recognition of only nine major categories of vegetation cover.[2] These are designated by letters A to I and almost invariably occur in combination. The latter are known as cover formulae, a few common examples of which appear in Fig. 2. Thus, an example of organic terrain like that shown in Fig. 3 can be completely defined as to cover type on the basis of formulae. The values of the letter symbols are transcribed largely in terms of plant stature, structure disposition and degree of woodiness.[2]

In recording the kind of cover it is important to indicate the area and shape of the sample of terrain under consideration. Fig. 1 shows two types

Fig. 1. Diagram showing space relationships for two major muskeg types. Note that sampling (e.g. small area in F 1) in arbitrarily selected areas (e.g. the outer limits of the diagram) must take into account cover formulae delineation.



of cover designated by cover formulae EI and FI. If the area selected for study is that shown as having the dimension *x* feet as its width, the quality and properties of the muskeg for which it would be symbolic would differ from those for which EI prescribes, and differ again were the area to overlap from FI into EI. In the case of FI, the peat would be constructed of a non-woody, fine-fibrous material existing with a high proportion of soft granules having no special shape. Where there is EI cover, it would represent peat structure also rich in non-woody fine-fibrous material, but with an abundance of woody particles much more resistant to compressional forces than are the shapeless (amorphous) granules. A transition condition occurs where the two cover types merge.

Only two types of structural condition are shown in Fig. 1. There are 16 that occur frequently. Each is characterized by its own set of properties. Besides these there are other features, for example, topographic ones, which are often diagnostic. Thus, where there is a peat of relatively coarse structure as compared to that beneath FI, it is often the case that ridges and mounds occur in the surface. In the spring these contain mounds of ice, producing a condition known as knolling.

The real key to relationship among surface cover, topography and peat category is found in a more specialized aspect of Palaeovegetography. It utilizes discreet microscopic units known as microfossils, biological indices that provide the means for historical and spatial sequence in the peat. Extensive study of these indices of organization has facilitated techniques of prediction concerning the structure of the terrain, and because of this circumstance, much information about a given expanse of organic terrain can be provided in a muskeg laboratory without reference to actual field experience.

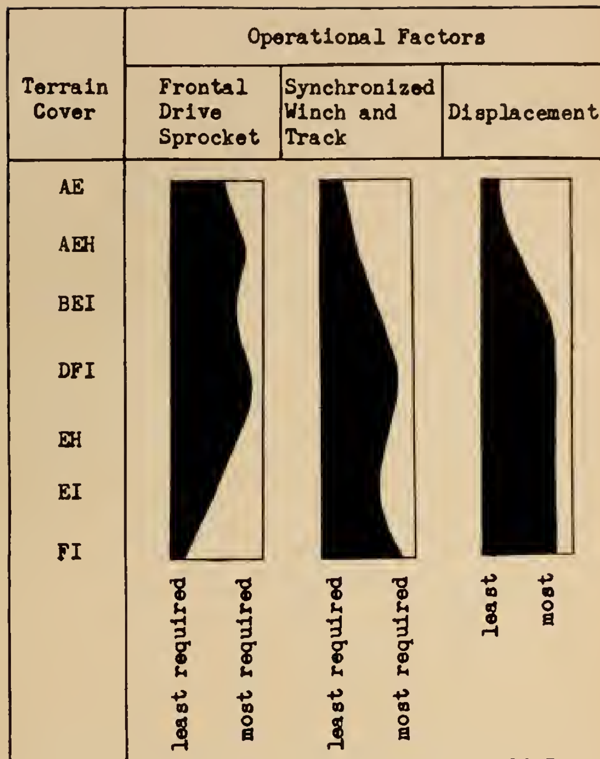


Fig. 2. Some common examples of cover formulae.

Fortunately, air-photo coverage is now available for the vast areas of organic terrain in the north. Now that it is known in general terms what cover formulae mean in relation to peat structure, stereo-pairs or mosaics of photographs showing ground cover can be used to predict structural conditions in the terrain. The highest altitude at which interpretation and prediction has been attained is at 30,000 ft. Obviously, at high altitude, cover formulae as they are known on the ground or at low altitude, appear to merge and any initial design that they effected gives rise to a new order of pattern. Detection of pattern, significant with reference to cover formulae, is a study in itself. The technique of detection has been explained elsewhere.[3, 4] Its application is essential if selection of route or any engineering development or operation in organic terrain is contemplated.

Usually route selection presupposes some knowledge of the fundamentals of Terradynamics. On the other hand, the latter is dependent upon the disclosures of Palaeovegetography. Thus, mobility on organic terrain is never adequate unless prescription for it is based on modern terrain interpretation. Indeed, failure is certain when the mechanical aids designed to achieve optimum mobility are carelessly and indifferently applied with respect to the type or types of muskeg encountered.

Fig. 3. Shown here is a typical example of organic terrain which, like all other categories of terrain, can be defined as to cover type on the basis of formulae.

Operations on muskeg reveal terrain variability of such unusual order that engineers and contractors are confronted with problems of a compound nature. A given vehicle operating adequately in one kind of muskeg and doing the work assigned to it will usually either fail or fall short of requirements on another kind of muskeg. There are now at least three types of vehicles that will successfully negotiate 90% of the terrain with EI cover shown diagrammatically in Fig. 1. The 10% that they will not negotiate is often so distributed as to effectively terminate an operation such as the construction of a road from an air strip to a drilling site or even delivery of supplies (for example, cement) where off-the-road access has been planned. For the FI cover the same vehicles would successfully traverse approximately only 50% of the terrain.

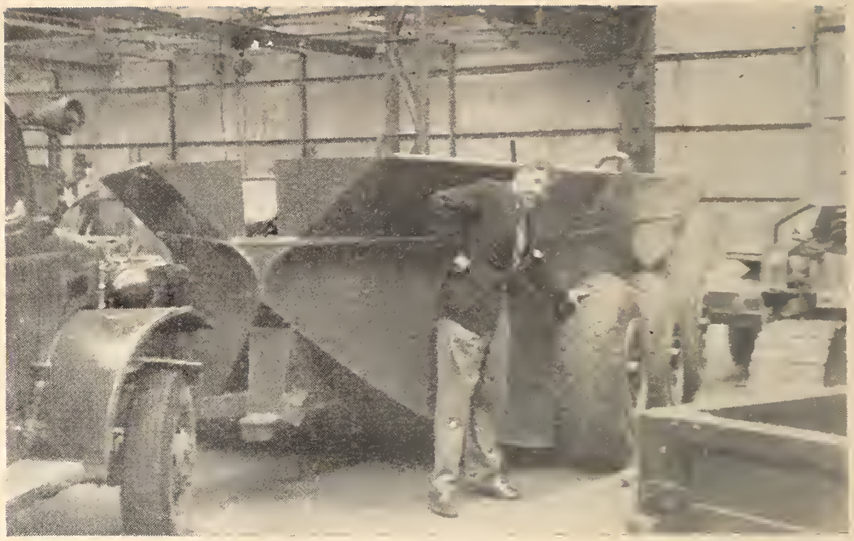


Fig. 4. A powered slipe. Note the aeroplane-type wheels which give greater buoyancy when the vehicle is on hard ground.

The reason for failure is usually twofold. One is that local terrain interpretation has not been adequate and the operator is uninformed or ill-advised. The other is that vehicle design is not sufficiently broad in its scope to accommodate for the diverse terrain conditions. It is a misconception that failure is always the direct result of a vehicle or vehicles sinking out of sight in the muskeg. Sometimes they sink only one or two feet and cannot be extricated either because of their own mechanical inadequacy or by reason of the fact that no device is available for pulling them out. Often it is not vehicle subsidence that limits an operation. It may be a characteristic terrain irregularity. Ice-knolling and irregular margins of peat plateaux are examples of this. The former condition is not only difficult to traverse, it is extremely hard on the drive and suspension mechanism of the vehicle. It is most devastating during the period April to June when the peaks of the knolls are at their highest amplitude (2-3 ft.). Distance between peaks is such that frequently the weight of the machine impinges on too few points on the tracks. This is accompanied by high frequency of impact of the track surface against the peaks. Because of this, steering is difficult and acceleration rate is constantly changing. The operator must be alert with the brakes and gears and must anticipate any embarrassment that might arise in manoeuvrability, especially if he is driving an articulated vehicle or if centre of gravity is inappropriate to terrain character. The degree of pitch that might be expected should be considered relative to characteristics of the cargo being transported or to the nature of the project under development.

Fig. 5. Here, a non-powered slipe is being drawn behind a powered unit: loads of up to ten tons can be hauled in these slipes.

Perhaps the best way to assess how much difficulty will arise in a given operation is to construct spatial diagrams appropriate to degree of limitation of terrain features and those mechanical features of the vehicles which the terrain will critically affect. An example of this suggestion is shown in Fig. 2. When these diagrams are placed side by side the general effect of the factors involved can be qualitatively compared for each terrain type to be traversed. In Fig. 2, two mechanical features and one operative effect imposed by the terrain are appraised for seven common terrain types. Normally, in any operation, at least these seven cover formulae would be encountered.

It is sometimes held that where the frontal drive sprocket is a design feature of the track vehicle there are distinct advantages. To be effective, the sprocket is so situated as to produce an inclined surface of track which meets obstacles in the terrain. A track approach angle therefore moves ahead of the vehicle facilitating elevation in the front of the vehicle. Also, with frontal drive, the lower run of track relaxes to the contour of the obstacle, thus affording maximum area of contact with the obstacle. This in itself assists traction and promotes uninterrupted progress. In addition, there is less likelihood of cutting the muskeg mat with the approach angle, and this is to be encouraged.

When the terrain mat is cut, even if as a result the vehicle does not completely subside, there is a good chance that it will lose traction, and winching will then be necessary. Where this situation arises, there is a high possibility of the condition worsening unless the speed of the tracks, which are kept rotating in the hopes of recovering traction, is approximately synchronized with the speed of the winch. Without this feature the vehicle noses down or up depending upon the speed relationship between the winch and track. This may result in unfortunate distribution of pressure and a change in ground pressure relations that may encourage subsidence.

Further examination of Fig. 2 shows that displacement brought on by subsidence is variable depending upon the type of muskeg as reflected in the type of cover. Note however, that of the seven types listed, displacement can be expected to be high in five of them. Even in the two remaining types, some chance of critical subsidence can be expected. The diagram expresses the relative frequency of subsidence to expect, not the amount of subsidence appropriate to each cover type. Therefore, it may only be said that where frequency of subsidence is high the degree of subsidence is apt to be great.

For muskeg with cover type AE the chances of displacement being frequent or considerable are very slight. Also, the need for synchronized winch and track speed is not essential. However, travel is much facilitated, as is manoeuvrability when a frontal drive sprocket is provided for in the design of the vehicle. Under the topographic conditions in this type of muskeg, angle of pitch for the vehicle can be expected to be high.

Accommodating mechanical features of vehicles to terrain requirements will not always make them faster. Usually it means that success in a given operation will be achieved as far as trafficability is concerned. An exception is when DFI occurs. Here, frontal drive sprocket, nearly synchronized winch and track speed are both highly desirable and often, in the opinion of the authors, essential. The need to accommodate for displacement is great. But if these requirements are met, speed of travel will be maximum and DFI is an excellent medium for travel.

Where EI and FI are concerned, displacement expectancy is very high. Indeed, it is in muskeg such as this that complete subsidence can be expected. With EI muskeg, extreme subsidence can be diverted if the frontal drive sprocket is incorporated as a design feature of the vehicle. For FI, this feature is not essential because the peat matrix is uniformly lacking in elements that can afford a means of traction once the upper surface of the mat is broken.

In the north generally, there are very large tracts of EI and FI cover. Although with modern muskeg transport equipment traverses and road construction can be achieved, it is not the normal situation to find that more than one or two passes can be made over exactly the same route. This has meant that the principles involved in Terradynamics have suggested a new type of design for transport where extensive EI and FI occur or where a traverse over this type of terrain is perhaps short but critical and used continuously.

The type of vehicle so far developed is known as a *Powered Slipe* (Fig. 4). It possesses aeroplane type wheels but these are only for buoyancy on hard ground when the vehicle is not progressing in muskeg Power is applied to a three-quarter inch cable anchored at either end or, for convenience, at intervals of about a mile. The cable is drawn in over the forward part of the hull of the slipe onto a capstan-type winch and run out behind the vehicle.

This method of travel depends upon buoyancy and never on traction. The breaking of the mat was discovered to have facilitated travel. Haulage of five to ten ton loads can be achieved in non-powered slipes (Fig. 5) drawn behind the powered unit.

The Slipe Haul system of travel in the far northern reaches of muskeg shows great promise. It is cheap; the cable is the road, and it can be salvaged when no longer required.

ACKNOWLEDGMENTS

Acknowledgment is gratefully made to the National Research Council, Associate Committee on Soil and Snow Mechanics and to the Defence Research Board, whose financial assistance have made possible the studies essential for the writing of this paper.

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GRAPHITE *(continued from page 49)*

packing materials must always be kept very small. The boron content, for example, must be less than one-tenth of one part in a million. Some idea of the need for these precautions may be gathered from the fact that reliable test results were impossible after a laboratory analyst changed his make of hair cream.

Grade 'A' Graphite

Seventeen months after the first bulldozer arrived on the site samples from a furnace load of completed graphite blocks were tested in a reactor by the United Kingdom Atomic Energy Authority. They were found to be of acceptable quality as Grade 'A' nuclear graphite and in addition met all physical and chemical tests. Since then experience gained in producing blocks for the first two nuclear reactors has confirmed that the original design and technique had been successfully applied. The product has been remarkably consistent with a capture cross section lower than had been anticipated for production material.

An intensive research and development program covering new materials, processes and methods of manufacture is being carried out to reduce the total cost of nuclear graphite in a reactor. Already promising results gained with the pilot plant have been confirmed by larger scale production. This work is especially important for the more advanced types of graphite moderated reactors now being planned.

SPECIAL FEATURES of the BRANDON GENERATING STATION

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Preliminary Studies

THE BRANDON Generating Station of The Manitoba Hydro-Electric Board consists of four 33-mw units designed for throttle steam conditions of 600 p.s.i.g., 825° F, and operating with a cooling tower to provide condenser cooling water. In view of the modern trend to large units operating at high steam pressures and temperatures, and considering the climatic conditions at Brandon with their effect on cooling tower operation, it is of interest to review the factors which afforded the selection of the site and the equipment.

The Manitoba Hydro-Electric Board supplies most of the power for the Province of Manitoba, and is responsible for providing new generating capacity as required to meet the demand. The power for the City of Winnipeg is distributed by the City of Winnipeg Hydro-Electric System, part of it being supplied by The Manitoba Hydro-Electric Board and the balance being generated in the City of Winnipeg Hydro-Electric System's own hydro and thermal plants.

The power for the Province of Manitoba outside of the City of Winnipeg is generated and transmitted by The Manitoba Hydro-Electric Board, but is distributed by the Manitoba Power Commission. For the purposes of system planning and operation, the two generating systems referred to above can be considered as a single entity.

Preliminary studies for the Brandon Station, which were carried out by The Manitoba Hydro-Electric Board and their consultants, were based on this conception. At the time these studies were made, the power generating capacity of The Manitoba Hydro-Electric Board and the City of Winnipeg Hydro-Electric System consisted of approximately 566,000 kw in hydro units on the Winnipeg River, and a 50,000 kw thermal station in Winnipeg. The bulk of the generating capacity was located at the eastern end of the system within approximately 60 miles of the Ontario-Manitoba boundary.

The study of the system indicated that the load could be divided into two basic blocks; the east block centred near Winnipeg and the west block extending from Portage La Prairie to the Saskatchewan border. Since the hydro sites, both developed and potential, are generally east and north of Winnipeg, it was apparent that there would be some advantages in locating the first thermal station near the centre of the western load block. A survey of the load distribution in this area indicated that the load centre was approximately 20 miles north of the City of Brandon.

Power transmission studies indicated that the generation of power in the Brandon area not only increased the stability of the system, but due to reduction of transmission losses, increased the net power available from the system. In fact, these studies showed that a 30 mw. unit at Brandon would be equivalent to a 40 mw. unit on the Winnipeg River.

A consideration of possible fuels indicated that lignite from the Estevan area of Saskatchewan would be most advantageous, and this factor also tended to favour the Brandon location over sites further east. Since that time, natural gas has become available, and under some conditions can be used to advantage, but the extent of its ultimate use will depend on the relative prices of natural gas and Saskatchewan lignite and the availability of gas.

It was realized that the Brandon site was not ideal with regard to the availability of cooling water since it would be dependent on the Assiniboine River. Unfortunately, the flow in this river is extremely variable, recorded flows ranging from a maximum of 23,000 cu. ft. per second to a minimum of 7 cu. ft. per second. A plant with a capacity of 132 mw., as was considered for Brandon, requires approximately 150 cu. ft. per second of circulating water. A combined cooling system using river water when available, and a cooling tower when required, was considered. However, this would have been more expensive than a closed system using the cooling tower at all times, and the added expense could not be justified. Moreover, since minimum river flow occurs in winter, it would still have been necessary to operate the cooling tower during extremely cold weather conditions. A closed system was therefore selected.

A review of the existing and predicted loads, both in the western area of the province and in the system as a whole, indicated that the Brandon Station should be designed for an installed capacity of approximately 132 mw. or a net output of about 120 mw. For comparison purposes, plants consisting of four 33 mw. units, three 44 mw. units and two 66 mw. units were studied. Many factors must be considered in selecting the optimum unit size to meet the system requirements. These include system reliability, the increase in firm system capacity, capital cost, fuel cost, and operating and maintenance costs.

The increase in firm system capacity, resulting from the installation of a 120 mw. plant at Brandon, varies with the size of the units used, and the results of the comparison are interesting and are listed in Table I.

Table I
Increase in Firm System Capacity

No. of Units	*Size of Units*	*Increase Over Existing System*
4	33	142 mw
3	44	126 mw
2	66	99 mw

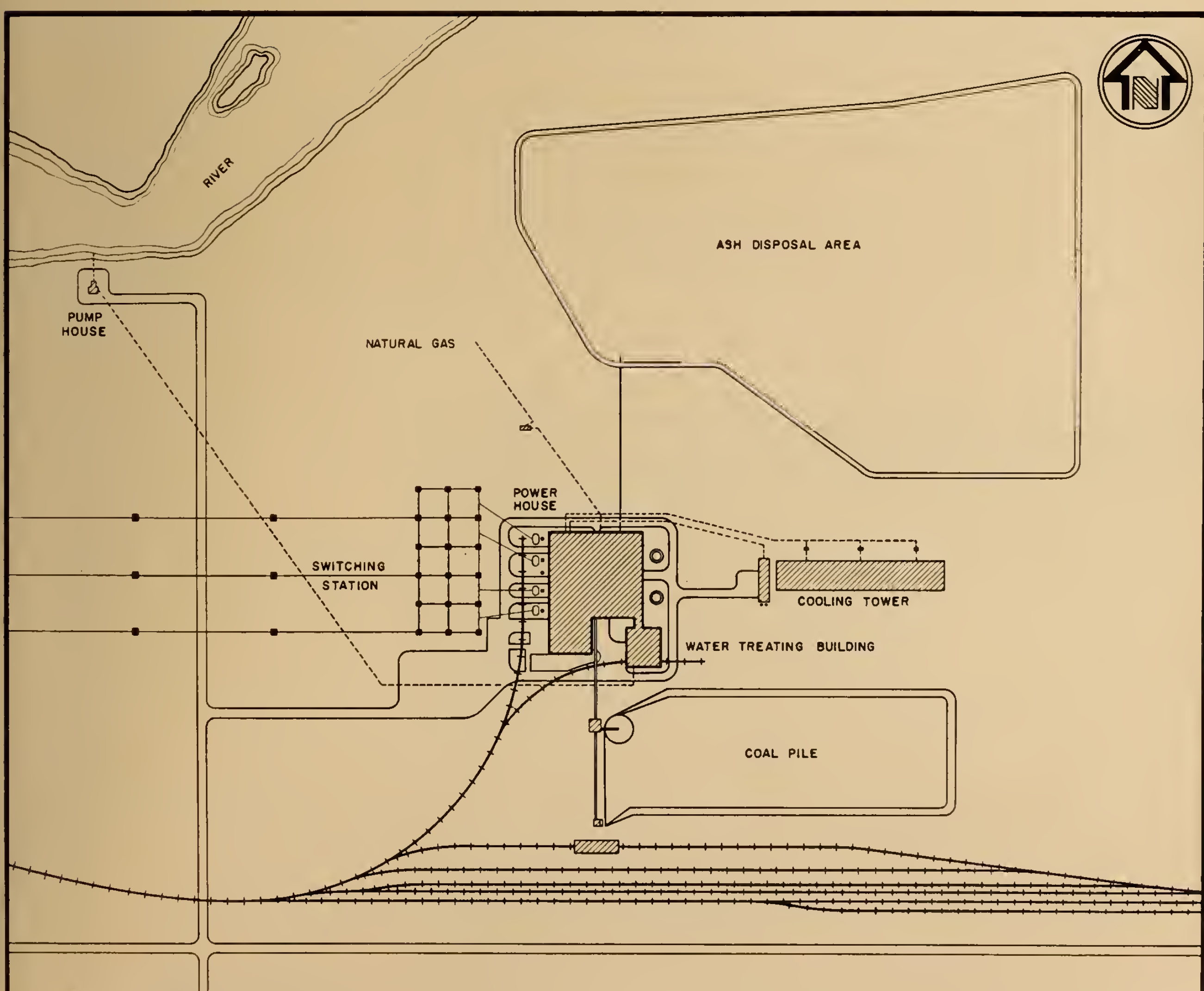
The increase in firm system capacity represents the increase in demand which the system can meet with the selected degree of reliability. The evaluation of this increase involves probability calculations with regard to forced outages of any one or more units in the system in conjunction with system peak demand studies. Although the trend indicated in Table I is normal since the required amount of reserve capacity is generally a function of the size of the units, the increase in firm system capacity is unusual since, in the case of the 30 mw. units, it exceeds the total capacity of these units. Although many factors are involved in the calculations, the main ones which resulted in the unusual increase in firm system capacity are:

(1) — Reduction of transmission losses.

(2) — Increase of the firm capacity of the hydro plants by providing more flexibility of operation, thereby permitting a more advantageous use of the available water storage facilities.

Studies of the system loads indicated that whereas the system load factor is approximately 57%, the expected average lifetime capacity factor for the Brandon Generating Sta-

Fig. 1. Brandon Generating Station—plot plan.



tion would be considerably lower or about 35%.

Detailed estimates of the total capital cost, fuel cost, and operating and maintenance costs were prepared for each of the three proposed unit sizes. The total annual cost per kilowatt increase in firm system capacity was then calculated. These calculations indicated that the optimum installation would consist of four 33 mw. units.

Further studies, which also involved comparison of capital cost, fuel cost, and operating and maintenance costs with turbine inlet steam conditions of 600 p.s.i.g. 825° F, 850 p.s.i.g. 900° F, and 1,250 p.s.i.g. 950° F, indicated that a plant operating with a turbine inlet steam pressure of 600 p.s.i.g. 825° F would be most economical for this installation.

General Description of Plant

The Brandon Generating Station is located on the south bank of the Assiniboine River, approximately 3 miles east of the City of Brandon. The arrangement of the site and location of the main buildings, cooling tower and switchyard is shown on Fig. 1. Fig. 1-A shows the general appearance of the office section and south side of the plant. Since the prevailing winds are from a westerly direction, the cooling tower is located on the east side of the main plant in order to reduce the spray nuisance.

The plant is designed on a unit basis, each unit consisting of a Metropolitan-Vickers turbine generator and condenser with a peak design rating of 33 mw, a Combustion Engineering-Superheater boiler with a design capacity of 325,000 pounds of steam per hour, and auxiliary equipment. The turbines are of the single cylinder impulse type with three extraction points and a single shell 2-pass condenser. The generators are of the hydrogen cooled direct-connected type, are designed to operate at 3,600 r.p.m., and are equipped with gear-driven exciters. The hydrogen system is designed for operation at a pressure of 15 p.s.i.g. at full load.

The boilers are of the tangentially fired type, designed for operation with either pulverized fuel, natural gas, or fuel oil. To date, only pulverized fuel and gas burning equipment has been installed, although there is provision for lighting off with light oil. Superheat control is provided by burner tilt, and attemperators have not been included.

The transverse section of the plant, Fig. 2, shows the relative location of the main equipment for each unit. Fig. 3 shows plans of the station at the operating floor and ground floor level. It may be noted that the arrangement of the equipment follows conventional lines. One departure consists of the provision of a totally enclosed central control room located on the operating floor between Units 2 and 3.

The plant feedwater heating cycle is shown on Fig. 4, and includes only three stages of heating. The cycle consists of two low-pressure closed feedwater heaters without drain coolers, but with a drip pump on the lowest pressure heater and a deaerating heater at the highest extraction pressure. This cycle, although not common for units of this size, has several advantages. It provides a reasonably high feedwater temperature and an acceptable efficiency while requiring a minimum amount of piping and controls. It is inherently simple and stable and, therefore, suitable for widely fluctuating load conditions and for two-shift operation. Furthermore, due to the relatively low average capacity factor anticipated for this plant, the extra cost of cycle improvements by the inclusion of additional heaters could not be justified economically. It should be mentioned that the operation of deaerating heaters at relatively high pressures as is done in this case presents a problem in maintaining sufficient net positive suction head to the boiler feed pumps under fluctuating load conditions. This problem, although beyond the scope of this paper, must be anticipated and provided for in the design of the plant, or the flexibility of the operation of the plant may be seriously impaired.

Fig. 1a. General appearance of office section and south side of Brandon generating station.

Water Supply System

As stated earlier, the fluctuations of flow in the Assiniboine River are such that a cooling tower is required. Since the evaporation rate in the cooling tower is approximately equal to the evaporation rate of the boilers, a considerable amount of make-up water is required. In the Brandon plant the cooling tower make-up water is obtained from the Assiniboine River. Unfortunately, the river water is very hard, with a degree of hardness varying between 200 p.p.m. and 900 p.p.m. The use of this water without treatment would result in rapid scale formation on the cooling surfaces of heat exchangers and condensers and in the cooling tower. This effect would, of course, be rapidly aggravated by the increased concentrations resulting from evaporation in the cooling tower. The system, therefore, includes a cold process lime softening plant in which all make-up water is treated. The system includes two reinforcing concrete treating basins, two lime feeders and slaker units, one soda ash feeder, one miscellaneous chemical feeder, control equipment and instrument panel. The system has a ca-

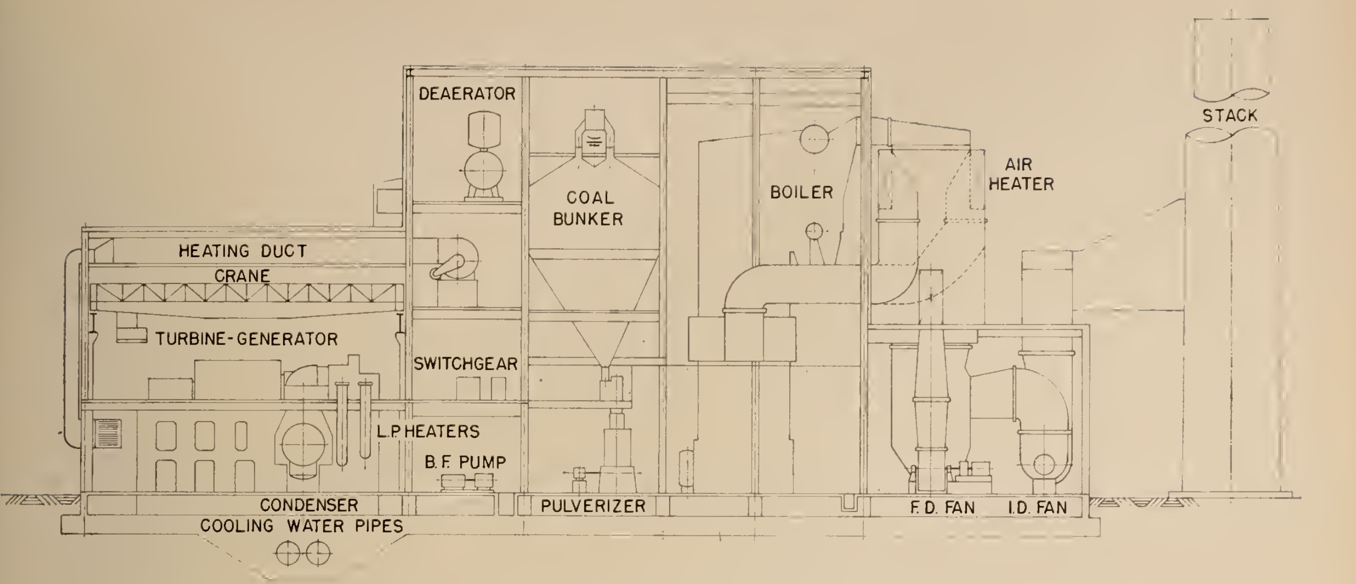


Fig. 2. Brandon Generating Station—transverse section.

pacity of 3,000 U.S.g.p.m., and is designed to reduce the calcium hardness to 35 p.p.m. and the magnesium hardness by 10 to 20%. The operation of this water softening system requires the use of relatively large quantities of chemicals, and storage bunkers are provided with capacities as listed in Table II.

Table II
Chemical Storage for Water Softening Plant

Chemical	*Capacity*	*Volume*
Pebble lime	130 tons	4,200 cu. ft.
Soda ash	42 tons	2,100 cu. ft.
Alum	60 tons	2,100 cu. ft.

In order to reduce costs, these chemicals are purchased in bulk, and a pneumatic car unloading system is provided to transfer the materials from the box cars to the storage hoppers.

Sulphuric acid and metaphosphate are used to control the corrosive and scale forming properties of the water, and to protect the cooling tower lumber against delignification. Although the water softening equipment is not unusual in design, it is probably the largest installed in a generating station in this country, both with regard to capacity and to the hardness of the water.

Demineralizing equipment is used for the treatment of boiler make-up. This was selected in preference to evaporators, partly because of the lower total operating costs and partly because of the expected intermittent plant operation. Demineralizing equipment unlike evaporators allows continuous production of make-up irrespective of plant or unit load.

Water from the Assiniboine River has a fairly high sodium content, averaging approximately 130 p.p.m. equivalent calcium carbonate. The possibility of sodium leakage seemed, therefore, to rule out the use of single stage demineralization. Consideration was given both to mixed bed demineralizers and to an *alternating series* arrangement. However, the system finally selected consisted of two complete lines of exchangers, each consisting of primary cation, primary anion, secondary cation and secondary anion units. A vacuum deaerator is installed ahead of the demineralizing equipment in order to protect both the demineralizing beds and the demineralized water piping from oxygen attack. Consideration was given to locating the deaerator between the primary and secondary units in order to take advantage of the reduction of chemical consumption due to the removal of carbonates at this point, but the added cost of making the deaerator corrosion-resistant could not be justified.

Cooling Tower and Circulating Water System

The cooling tower was supplied by Foster Wheeler Limited, and is of the induced draft type with 24 cells. Each cell is approximately 32 ft. square and 39 ft. high, so that the overall dimensions of the tower are 385 ft. by 70 ft. Each cell is provided with an exhaust fan with a capacity of 360,000 c.f.m., and provisions are made to operate these fans at half speed and in the reverse direction. The tower is designed for a water flow of 75,000 U.S.g.p.m. at an inlet temperature of 112° F, outlet temperature of 82° F with a wet bulb temperature of 72° F.

The optimum size of cooling tower and condenser combination was determined from economic studies. In making these studies a wide range of sizes of cooling towers and condensers was selected, and complete performance characteristics were worked out for each. The amounts of energy produced at each circulating water temperature were calculated, and from detailed estimates of capital costs of equipment, cost of pumping power and the cost of energy produced for each combination, the total annual cost for fixed charges, power and fuel was determined. As a result of these studies, a cooling tower as described above was selected with a ground area of .186 sq. ft. per kilowatt.

The condensers have an effective condensing surface of 15,000 sq. ft. per unit or approximately .455 sq. ft. per kilowatt. Both the cooling tower ground area and condenser surface are somewhat smaller than normal, but this again is the result of the low plant load factor and fuel cost.

The circulating water system consists of a closed loop with circulating water pumps pumping the water from the cooling tower sump through the condensers and back to the top of the cooling tower. The hydrogen coolers and turbine oil coolers are connected in parallel with the condensers. The four circulating water pumps have a capacity of 19,000 U.S.g.p.m. per pump against a total head of 65 ft. These pumps are located in a pump house adjacent to the cooling tower, and two 60 in. diameter buried steel pipes are provided for the water supply and return system.

The total number of circulating water pumps required at any one time depends on the load on the units and circulating water temperatures as determined by the wet bulb temperature. Under some conditions it is possible to operate all units at full load with only three circulating water pumps, whereas under other conditions it may be advantageous to operate the four circulating water pumps even though the station is operating at less than the rated capacity.

The circulating water pumps may be started and stopped from the central control room, and valve position interlocks are provided to protect the equipment. Valves are also provided to permit isolating sections of the cooling tower, and the cooling tower fans are controlled from the central control room.

Lignite Handling and Burning

As mentioned previously, the Brandon Station has been designed primarily to burn lignite from the Estevan area of Saskatchewan. The characteristics of this fuel as used for design purposes are given in Table III.

Table III
Characteristics of Lignite

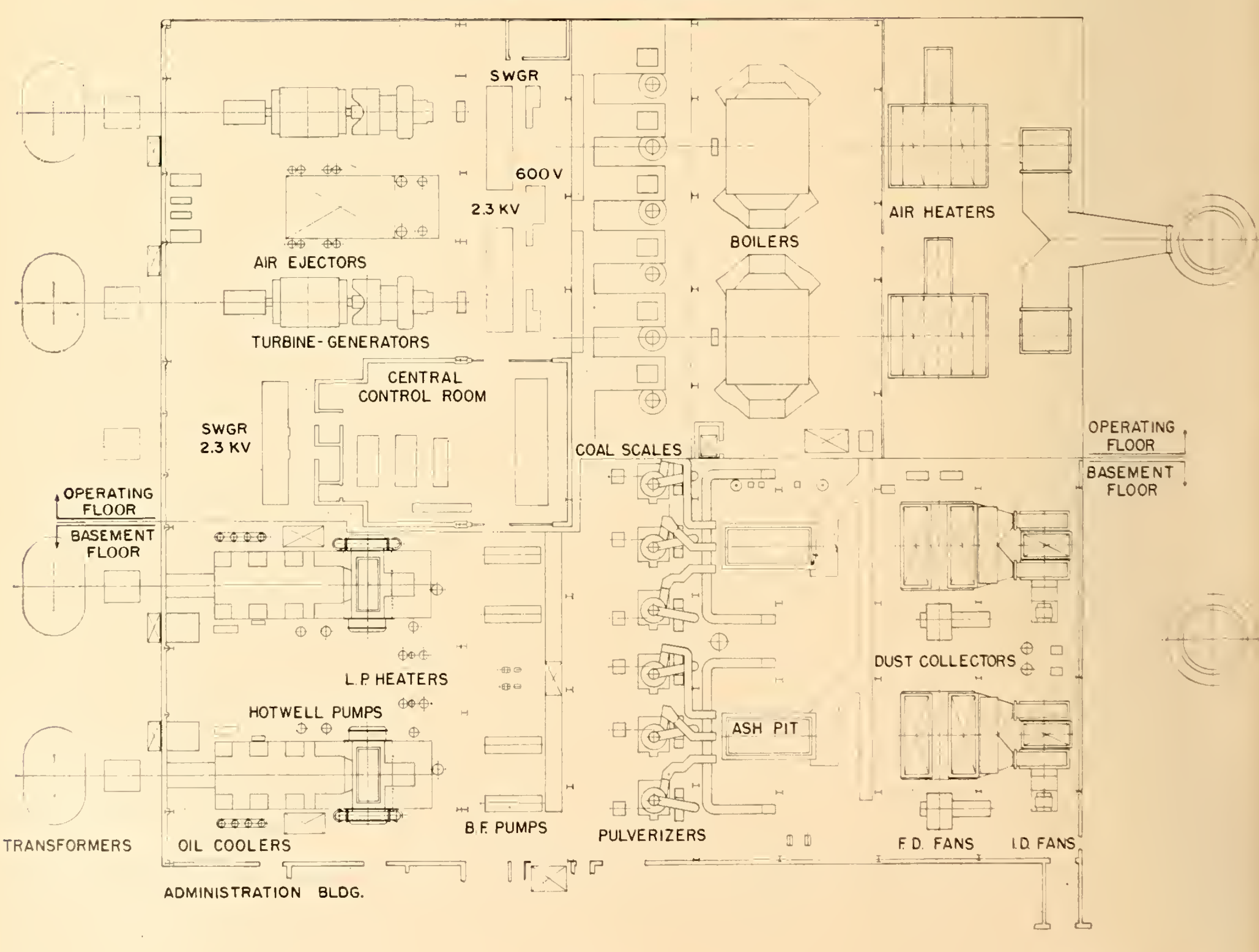
	Normal	*Worst*
Moisture	33.5	40.0%
Volatile material	26.0	21.5%
Fixed carbon	32.0	26.5%
Ash	8.5	12.0%
	100.0	100.0%
Sulphur	—	0.7%
Btu per pound (as fired)	7,100	5,900
Ash softening temperature	—	2,050° F
Grindability (Hardgrove)	55	50

It will be noted that this fuel has a very high moisture content and a correspondingly low heating value. Practically all of the moisture is in the *inherent* form. Surface moisture in the fuel is usually quite low and, in fact, the dust problem is somewhat greater with Saskatchewan lignite than with more usual fuels.

While at the time when the Brandon Station was designed there had been considerable experience in the use of Saskatchewan lignite on travelling grate and spreader type stokers, very little information was available on its use in pulverized fuel installations. The information that was available seemed to indicate that it presented no special difficulties although its behaviour was in some respects different from other fuels.

With bituminous coals it is generally necessary to supply air to the pulverizers at a temperature sufficiently high so that all of the moisture in the coal can be evaporated and the coal-air mixture delivered to the burners at a temperature of 150-160°. If this were true of lignite an extremely high air temperature would be required. However, information obtained from plants burning North Dakota lignite indicated that this fuel could be pulverized and burned

Fig. 3. Brandon Generating Station—plan.



quite satisfactorily while still retaining the greater part of its inherent moisture. The coal-air mixture in such installations may leave the mills at temperatures of 110-120° F.

Approximately at the time these units were purchased, tests were carried out on several car loads of Saskatchewan lignite in the plant of a power and light company at Aurora, Minnesota. The results of this test, which were reported in the December 1954 issue of *Combustion,* served mainly to confirm what was already known about the burning of lignite, and provided much of the detailed performance information on which the design of the Brandon boilers was based. No difficulty was experienced during the test in changing over from bituminous coal to lignite nor was any difficulty encountered in operating the pulverizers at maximum capacity with the pulverized fuel retaining as much as 26% moisture. There were some indications that fouling of the furnace walls took place somewhat more rapidly than with bituminous coal, but this did not appear to be a serious difficulty.

Due to the somewhat greater experience with this type of equipment, some consideration was given to the installation of spreader stokers at Brandon. However, this would have meant either that stokers of unusually large size would be required or that two boilers per turbine would be needed. Neither of these alternatives seemed particularly attractive, and since the information available indicated no real problems in the burning of pulverized lignite, the decision was made to install pulverized fuel units.

The units installed are quite conventional and include three bowl type mills per unit supplying tangential burners. Furnaces were designed for a heat release of about 90,000 B.t.u. per sq. ft. of furnace envelope. Provision was made for the installation of furnace wall soot blowers, but these were omitted from the initial installation with the thought that they could be installed later if experience proved them necessary. Air heaters were designed to supply air to the pulverizers at 620° F, and this was thought to be adequate for satisfactory pulverizer operation. However, provision was made for the installation of ductwork to permit hot gas to be withdrawn from the furnace bottom and mixed with the primary air if this should prove necessary or desirable.

Low heat content of the lignite

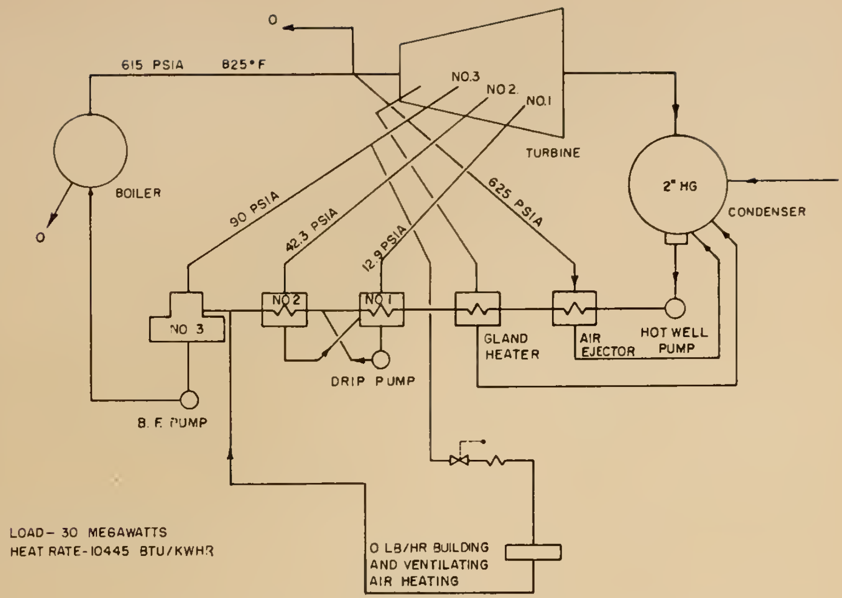


Fig. 4. Brandon Generating Station—cycle diagram.

necessitated the provision of an unusually large coal-handling system and bunkers. Based on a maximum daily load factor of 80%, the estimated maximum coal consumption is 2,400 tons per day, and the coal conveying system is designed for a capacity of 400 tons per hour, thus providing for one-shift operation of the coal-handling system.

All the coal is brought in by rail in bottom dump cars, and a car shaker is provided to expedite the unloading and facilitate handling of frozen coal. A stocking-out conveyor permits the stock piling of coal. Coal in the stock pile is handled with conventional mobile equipment such as bulldozers and carry-all scrapers. The coal bunkers have a capacity of 3,000 tons which is sufficient for 30 hours operation.

Centralized Control Room

All the main controls for the four units, switchyard, and common auxiliaries are located in the central control room on the operating floor between units Nos. 2 and 3. This room is air conditioned, and care was used in selecting materials and construction to reduce the noise level as far as practical.

No attempt has been made to provide for complete remote control of the plant. However, sufficient instruments are installed to permit the control room operator to direct operations in the plant by means of a *PAX* telephone and paging system. Such an arrangement permits a considerable reduction in operating staff since operators outside the control room need not be stationed in fixed locations, but are available to carry out duties in any part of the plant as directed by the control room operator. The reduction of staff is believed to be more than sufficient to pay for the added cost of centralizing the controls in this fashion.

The boiler and unit control panel is of the walk-in type with all control switches and manual controllers on the bench section forming an integral part of the panel. Furnace flame viewing television units, drum water level indication, annunciators, as well as all the necessary indicators are located on the vertical front portion of this panel. Three miniature recorders for each unit for steam-flow air-flow or gas-flow air-flow, drum level and steam temperatures are also located on the front portion. All recorders which are not required for normal operation are located on the back of the panel. Fig. 5 shows the front of this panel.

This arrangement has several advantages. The space required for the instruments and controls is reduced to a minimum as may be noted from the fact that the instruments and controls for four units and the common auxiliaries are grouped on a panel with a total length of 31 ft. 1½ in. Also, this arrangement permitted shipping the panels with all instruments and control relays, etc., completely piped and wired to terminal points at the bottom of the panel at a considerable reduction of field installation time and cost.

The combustion controls are of the conventional pneumatic type.

Although it is not possible to start up a unit from the central control room, most of the necessary controls have been provided for normal operation. These include controls for starting or stopping of boiler feed pumps, condensate pumps, fans, pulverizers, igniters, etc. Boiler purge interlocks and other safety features have been incorporated in the system to ensure safe operation under all reasonable conditions. Initially, coal failure alarms were provided which operated from the mill coal feeders and the coal scales. Recent experience has shown that a satisfactory indication of flame failure can be obtained from furnace draft, and the fuel systems have been interlocked with the furnace draft.

Heating and Ventilating System

The heating and ventilating system for a steam power station has two main purposes:

(1)—To maintain comfortable temperature conditions for the operating personnel.

(2)—To provide combustion air to the units.

The two functions may be treated separately in which case air for the forced draft fans may be brought in directly from the outside, heated and delivered to the unit while a separate system provides heat and ventilation for the plant; they may be combined in such a way that the forced draft fans withdraw air from the building and provision is made for introducing an equivalent amount of air at the proper temperature into the building; or some combination of the two schemes may be adopted. At the Brandon Station the second arrangement, combining the two functions, is used. Its advantages in producing more uniform building temperatures, due to the large volume of air passing through the plant, was felt to justify the somewhat greater cost.

The arrangement of equipment is indicated on the cross section and includes fresh air intakes at a point just above the turbine room roof, recirculated air intakes at the top of the boiler room and plenum chambers, heating coils and fans supplying air to the turbine room. From the turbine room some of the air passes across the building to the forced draft fan inlets and some flows upward to the recirculated air intakes.

Heat when required is supplied primarily by steam heating coils taking steam from the top extraction point on the turbine. Since the fans and heating coils are arranged on a unit basis, condensate from these coils can be returned directly to the main unit condensate system.

When all main units are shut down or operating at very low loads, the pressure at the turbine extraction point is not sufficient to supply the necessary heat, and it is necessary to provide some alternative source. In the Brandon Station a hot water heating boiler operating at atmospheric pressure is used. As compared to a steam boiler this has a number of advantages. Most important are:

(a)—Such a unit can be operated safely and completely automatically without attention from the operating staff.

(b)—By using hot water as the medium for distributing heat to the units that are out of service, cross connections between the steam and condensate systems of different units can be avoided.

When one or more turbines are in operation, it is more economical to supply all of the heat from these units rather than from the heating boiler. To permit this to be done, hot water converters are provided. supplied with steam from the turbine extraction.

The office section of the plant is heated by means of the same hot water system that supplies the main plant.

To provide additional ventilation in the summer period, a number of roof ventilators are installed in both the turbine room and boiler room.

Station Electrical Features

Fig. 6, shows the essential features of the plant. There are four main voltage levels utilized, which are broadly broken down as follows:

13,800 volts — Generator output voltage.

2,300 volts — For heavy auxiliary motor drives.

550 volts — For lighter duty auxiliary motors.

110/220 volts — For lighting and small auxiliary motors under $\frac{1}{4}$-horsepower.

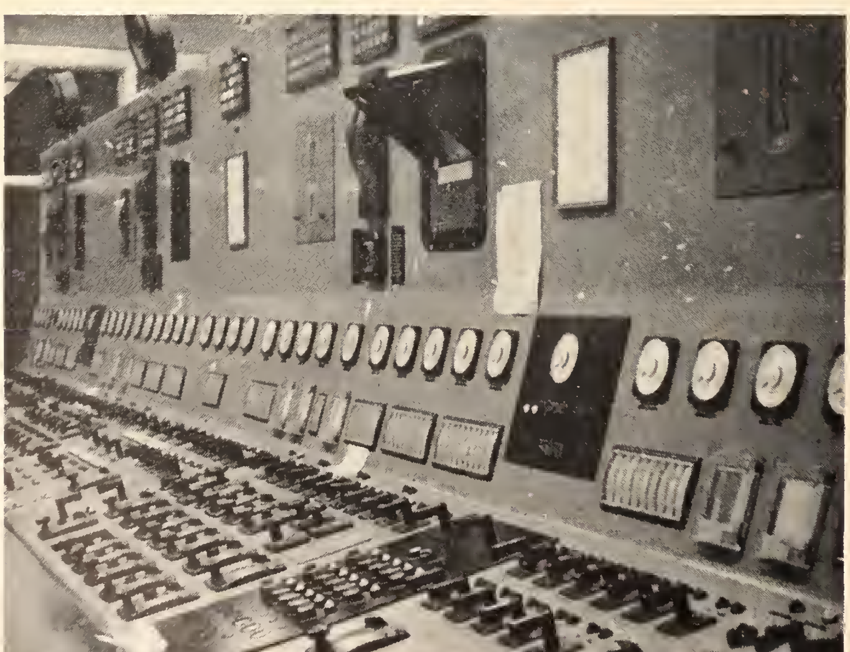
The main generator voltage is stepped up to 115 kv. for connection into the high-voltage distribution system. Provisions were made in the original design for additional 115 kv. lines and for a future 230 kv. expansion without major modifications to the existing layout.

In normal operation all unit auxiliaries are supplied with power by the unit, and auxiliary power requirement with the unit operating at full load represents about 6.5% of the generator output.

Alternators

For purposes of design it was considered that the generator and its associate step-up transformer would be considered a unit. Although the generator output voltage is 13.8 kv., it is immediately stepped up to 115 kv for utilization or distribution in the switchyard. The turbines and

Fig. 5. Front of boiler and turbine control panel.



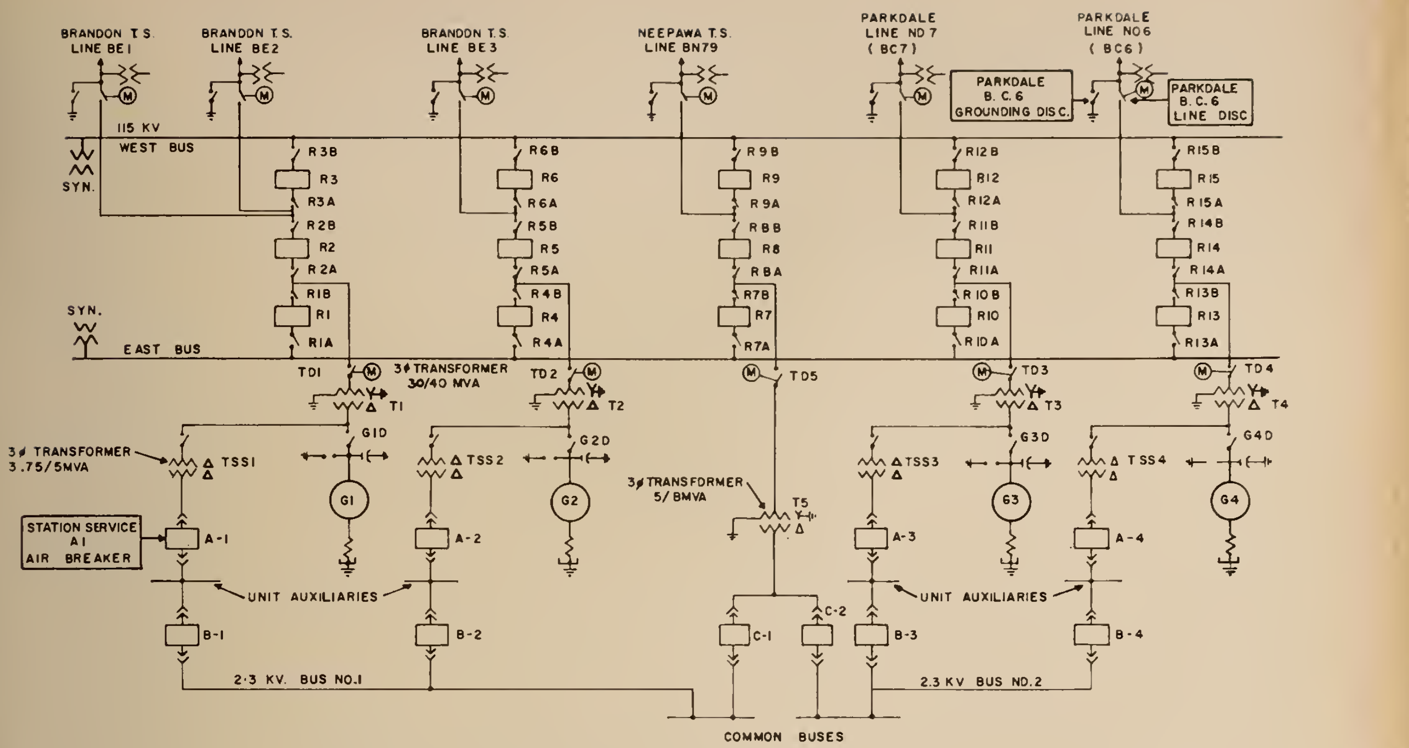


Fig. 6. Brandon Generating Station—electrical single line diagram.

alternators have a rating of 33,000 kw. The unit main transformers are three-phase transformers rated at 30,000-40,000 kva. The output of the unit transformers is connected to the high-voltage bus. The switchyard itself is termed an element and one-half bus which is becoming extremely popular on this continent because of the ease with which various elements may be removed from service for maintenance. The schematic diagram covering the high-tension features of the switchyard are also covered on Fig. 6.

The short circuit ratio of the Brandon generators is 0.8 which is common for machines built in this country, but a short circuit ratio of 0.5 is more usual in machines of European design. A short circuit ratio of 0.8 results in a low reactance machine and inherently greater system stability. Network analyzer studies indicated this to be desirable.

The high-voltage breakers located in the switchyard were among the first high rupturing capacity air blast breakers manufactured in Canada. At the time of purchase this type of high-voltage breaker was the only one manufactured which had the protective current transformers built into the breaker. This resulted in a considerable saving in switchyard structural steel. The rupturing capacity of these breakers is rated at 3,500 mva. with a total interrupting time to arc extinction of 5 cycles.

As with any station of this type, the design of the excitation system for the generators must tie in closely with system features. The voltage regulators associated with the generator exciters at Brandon are of the continuously acting static type. In this particular case, magnetic amplifiers were used to control the generator terminal voltage conditions through exciter auxiliary *boost* and *buck* windings. It was found that by adopting this type of control that pilot exciters were not required, at a considerable reduction in equipment and cost.

Generator Protection

The relay protection for the generator is generally consistent with that found in plants of this type on this continent and consists of the following:

(a)—Overvoltage protection
(b)—Voltage restraint overcurrent protection
(c)—Differential protection
(d)—Field ground protection
(e)—Reverse power protection
(f)—Negative sequence protection
(g)—Loss of field relay protection.
(h)—Station ground protection.

There are also two other types of relaying in connection with the voltage regulator such as underexcitation limit relay and a discriminating relay for protection of the generator and the system in case of a potential fuse failure on the regulator system.

Transformers

There are two types of transformers employed at the Brandon Generating Station. These are oil-filled, fan-cooled outdoor transformers and air-cooled indoor types.

The oil filled types were employed for the main unit transformers and the unit auxiliary transformers. Except for the two supplying the circulating water pump house, all step-down transformers from 2,300 v. to 550 v. and from 550 v. to 110 220 v. are of the air cooled type, and are located inside the power house where temperatures are relatively constant. The two 2,300 500 v. step-down transformers supplying the circulating water pump house are of the oil filled type.

Auxiliary Power

The induced draft fans, forced draft fans, boiler feed pumps, pulverizers, and other unit auxiliaries are supplied from the generator output on a unit basis. Obviously it is necessary to start the unit with power obtained from a station service or start-up transformer. This start-up transformer also supplies such common services as the circulating water pumps, cooling tower fans, coal-handling equipment, etc. This means that after a unit is supplying power it is necessary to *throw over* the unit auxiliaries from the start-up source to the unit source. This is accomplished at the Brandon Generating Station by the *dead transfer method*, so that when one source is tripped off there is a 45 cycle time delay before the second source is closed in to re-energize the motors. It has been proved by tests that after a 45 cycle delay the residual voltage due to the running motors has sufficiently decayed to allow a smooth restart-up to occur. This method of transfer makes a transfer scheme extremely flexible in a station of this type, and keeps the system relatively simple as no synchronizing of power sources is required.

There is, however, the inherent problems of drop out of low-voltage magnetic motor starters with the delayed transfer method. This problem was overcome by use of *latched in* starters so that the motor contactors remain closed during the transfer and all motors are re-energized automatically.

Remote Control

The water treating and coal-handling equipment are not controlled from the central control room, but rather are controlled from local control centres located within the water treatment building and crusher house respectively. The controls for all 550 v. auxiliaries located within the main plant have been centralized in the central control room using a 120 v. a-c. control voltage.

All 2,300 v. motors are controlled by means of the 250 v. d-c. station battery. As mentioned previously, there are several remote buildings containing motor drives whose operation are dependent on general plant conditions and which it is desirable to control from the centralized control room. In order to overcome the excessive voltage drops encountered by using a-c. control voltages, it was decided to use the station battery voltage of 250 v. d-c. for the control of all motors in remote buildings. This remote control covers such items as the raw water pumps, the cooling tower fans, etc.

One interesting feature is the control of the cooling tower fans. There are 24 fans on this tower, each capable of being run at slow speed and fast speed forward, and at a slow speed only in the reverse direction. Since the circulating water system is arranged to supply water to the cells in groups of four, the fan controls are also arranged in the same groups of four. In this way only six control switches are required in the central control room, although indicating lights are provided to show the fan speeds and the total number of fans in operation. Controls are provided at the cooling tower to permit individual control of each fan for maintenance or other purposes.

Station Batteries

The main station battery has an output voltage of 250 v. d-c. used mainly for circuit breaker control. There is also a stand-by battery of the same capacity, and throwover facilities are available to use the standby battery as the station battery, if required.

Emergency lighting and essential auxiliaries are also carried by the station battery in case of a-c. failure. This lighting is sufficient to permit plant operation on failure of normal lighting services. A 48 v. battery is also provided for annunciation purposes.

Communications

The plant has been equipped with an internal *PAX* telephone system for communication within the plant. This system can be tied in by use of a carrier system on the transmission lines for communication with the Winnipeg office. In conjunction with the *PAX* system is a paging system by which any telephone within the plant can be used to issue operating orders.

Operating Experiences

The first unit of the Brandon Station went into service in November 1957, and the fourth and last unit was commissioned in September 1958. Operating experiences to date have disclosed no serious difficulties.

Although there was some fear in the beginning that lignite might be difficult to store because of its tendency to catch fire by spontaneous combustion, this has not proved to be a problem. By compacting the coal carefully when it is put into storage, the tendency to overheat can be completely eliminated. Some minor difficulties were encountered in the early days due to the pile being formed with sides that sloped too steeply to permit proper compaction, but these difficulties were eliminated by simply decreasing the angle of the slope.

Lignite does tend to catch fire if left too long in the bunkers, and care must be taken to see that the storage time does not exceed about two weeks. Due also to its tendency to overheat in the bunkers, a considerable amount of gas is evolved and thorough ventilation of the space above the bunkers is required. This ventilation serves the further purpose of reducing the dust problem which has proved to be quite severe with the fuel encountered to date.

In its burning characteristics lignite has produced no real surprises. The major difficulty to date has been that the furnace tends to foul up rather rapidly with the result that steam temperatures during preliminary operation were excessively high, and there was a tendency for deposits of the bonded type to form in the superheater and convection zone. However, wall soot blowers have now been installed and by frequent operation of these blowers, it is possible to maintain clean surfaces in the furnace. When this is done the other difficulties disappear.

The fly ash from lignite has an unusually strong tendency to adhere to air heater and dust collector surfaces. In the case of the air heaters this has resulted in poorer performance than would be expected with other grades of fuel. In the dust collectors deposits have been experienced on the tube sheets and at the outlet cones of the collecting tubes. To avoid deposits in the latter location the outlet cones have been removed. This probably has the result of reducing the dust collector efficiency to some extent, but this is not considered serious.

As was to be expected, operation of the cooling tower in winter is not without its problems. Winter temperatures in Brandon are below zero most of the time, and fall to 30 below for about 2½% of the time. This results in severe icing, and the problem is aggravated by the intermittent nature of the load that the plant is required to carry.

The cooling tower fans are arranged for two-speed operation and can be reversed for de-icing purposes. While it has been possible by reversal of air flow, by closing the louvers over part of the intake area, and by varying the number of cells in operation, to keep the formation of ice more or less under control, the labour involved has been considerable. Furthermore, cooling water temperatures have been higher during the winter months than would be desirable. It is expected that further experience in cold weather operation will develop ways and means of improving these conditions.

CBC TELEVISION NETWORK PROGRAM DELAY CENTRE

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This paper discusses the geographical problems which prompted the Canadian Broadcasting Corporation, at the beginning of 1956, to undertake the project of providing a center along the coast-to-coast microwave network at which television programs could be delayed and later re-broadcast. Decisions which had to be taken regarding the quantity and layout of the equipment required are discussed, together with the problems attendant upon a double replay at closely spaced intervals.

The performance of the system is assessed, insofar as this is possible with equipment which has been in use barely six months, and mention is briefly made of the staff requirements for such an installation.

INTRODUCTION

IN A LAND as vast as Canada, problems arise in radio and television network operations which are not met in geographically smaller countries. Canada spans the North American continent from Newfoundland (longitude 55°W) to Vancouver Island (longitude 125°W)—a distance of approximately one fifth the circumference of the earth at the 49th parallel—and thence still further westwards to the Yukon (longitude 135°W).

Consequently, in Television Network operations a program' timing problem becomes apparent since there is a total time difference between Newfoundland and Vancouver of four and one half hours, which in

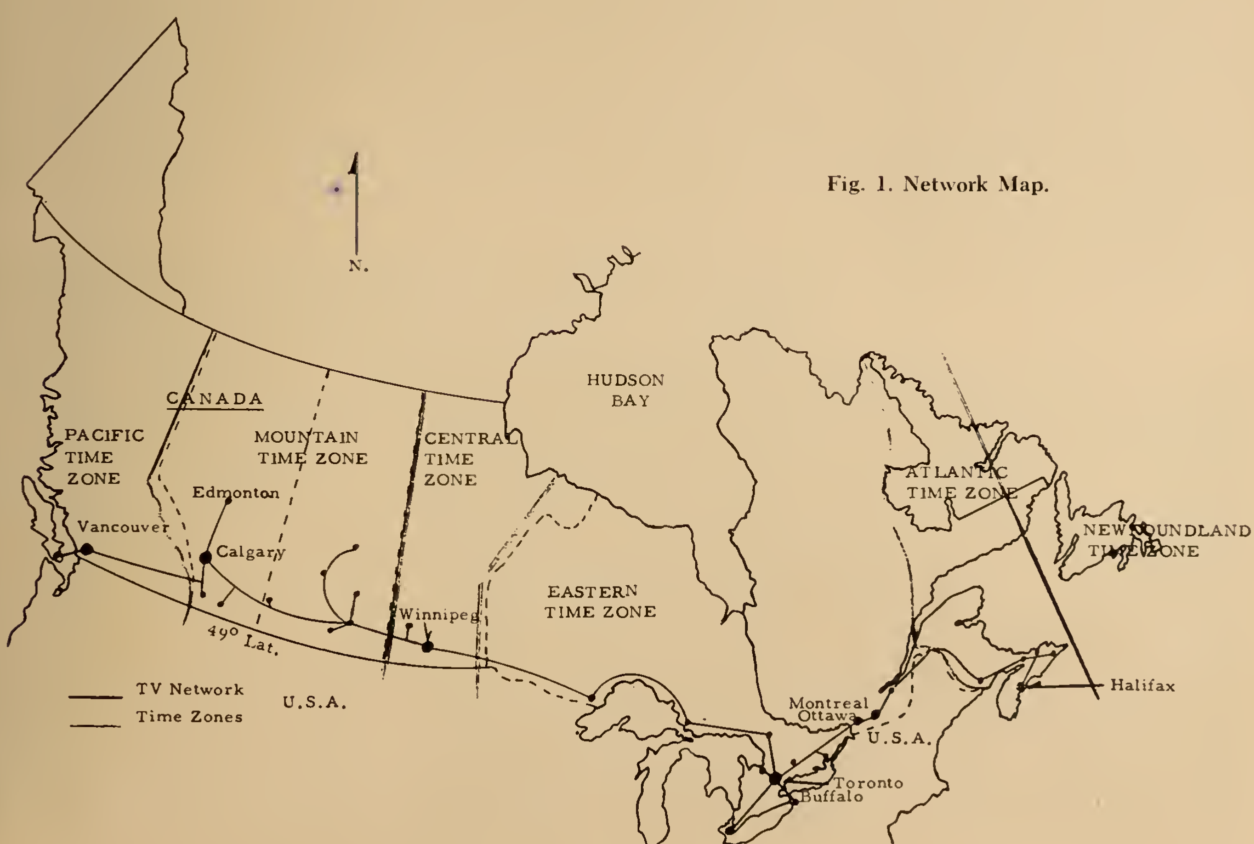


Fig. 1. Network Map.

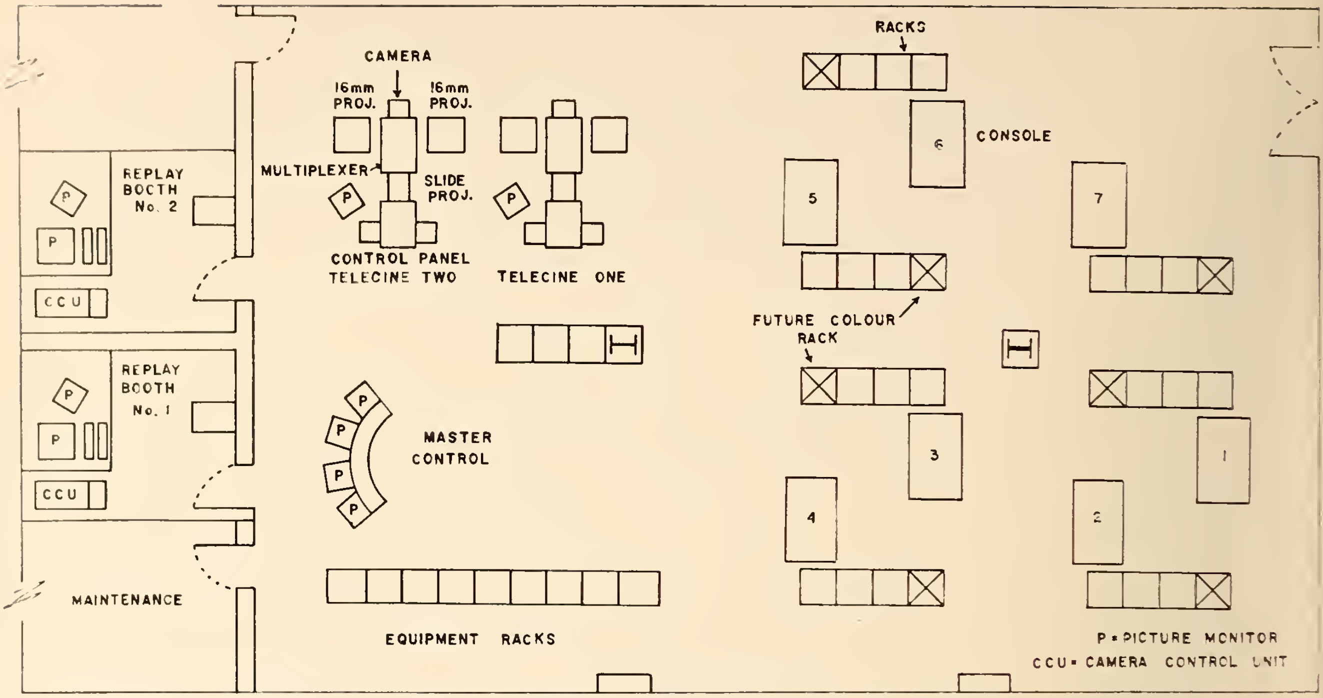


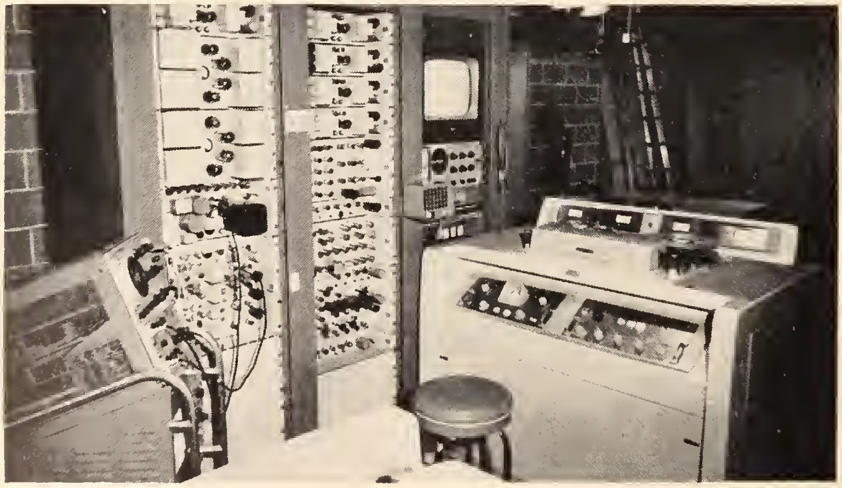
Fig. 2. Equipment Layout.

turn is divided between six time zones (see Fig. 1).

The majority of the English language television programs carried on a network basis originate in Toronto, and this is also the point of entry into the Canadian network for programs originating in the United States. Because of this, for the purposes of program timing all zones westwards are referred back to Toronto (i.e. Eastern Standard) time. The Maritime Provinces on the east coast are one hour ahead of Eastern Standard Time, while Newfoundland is one and one half hours ahead. The major problems arise when programs are fed westwards along the microwave network as far as Victoria, British Columbia, where the time is three hours behind Eastern Standard Time. Clearly, any future extension of the network into the Yukon will compound the problem by an additional one hour time difference.

In order to compensate for these time zone differences it is desirable to provide some method of recording programs. This would permit a program being aired at, say, 8 p.m. in the Eastern Time Zone (the peak evening viewing period) to be rebroadcast at 8 p.m. in the Mountain Time Zone (two hours later) and also at 8 p.m. in the Pacific Time Zone (three hours later). This point assumes considerable importance when viewed in the light of the saleability of air time to sponsors of the bigger commercial *spectaculars*.

Fig. 3. Video Tape Recorder.



To complicate matters still further, the timing pattern outlined above is subject to variation during the summer months, since stations in the Province of Alberta remain on Standard Time, while most stations in Saskatchewan and British Columbia change to Daylight Saving Time by advancing their clocks one hour. Further variations arise during the fall when western Canada has reverted to Standard Time while eastern Canada remains on Daylight time until the end of October. During this latter period, delays of three hours for the Mountain Time Zone and four hours for the Pacific Time Zone must be provided.

Alternative methods of providing the required delay

It was with the foregoing complexities of program timing in mind that thinking proceeded in the early part of 1956, directed towards possible methods of providing the required time delays. At that time the only proven and practical method of recording television programs for subsequent rebroadcast was by film—i.e. the well-known kinerecording system. Provisional plans were drawn up for a system incorporating kinerecorders, rapid film processing facilities and rebroadcast by means of a telecine film chain. From the start it was apparent that such a system would be complicated, unreliable and expensive to operate. In addition, studies indicated that it would only just be possible to operate with a minimum delay of two hours between recording and rebroadcast.

In April 1956 the Ampex Corporation of California demonstrated a prototype video magnetic tape recorder and it was immediately apparent that herein lay the solution to television network delay problems. Nevertheless almost two years were to elapse before the prototype video tape recorder had been developed into a production machine capable of being integrated into a television system.

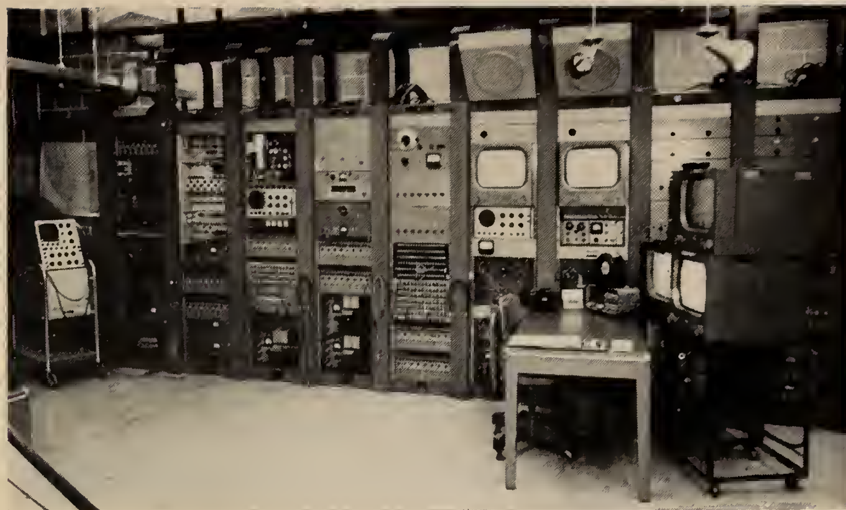


Fig. 4. Test Facilities in Master Control.

Selection Of Delay Centre Location

Meanwhile, the management of the Canadian Broadcasting Corporation had been making a detailed study to determine the optimum location of the proposed TV Network Delay Centre. Problems of capital cost, running costs, duplication of Network facilities, staffing, etc. were all considered and eventually the City of Calgary, in Alberta, was decided upon as the most suitable location. Reference to the network map will show that Calgary is located on the main microwave network at the junction of the northern leg to Edmonton with the western leg to Vancouver.

Thus it was decided to set up a Television Network Delay Centre which would be a vital part of the Canadian Television System, and in January, 1958 some 5000 sq. ft. of space was leased in the newly completed Alberta Government Telephone building in Calgary for this installation. This proved to be a happy choice, since power and lighting were available and the air conditioning equipment was already installed; furthermore, the TV Network microwave operating centre in Calgary was housed in the same building, three floors above the space leased for the Delay Centre.

Building work began in mid-February 1958 and was completed by the 1st of April, when installation of the technical equipment commenced. The operational target date was already fixed for July 1st, 1958, at which time the last section of the microwave network from Calgary to Vancouver would be completed and ready for use.

Equipment Layout and Installation

In planning an installation of this nature—the first of its kind in the CBC system, some problems concerning equipment layout presented themselves. At first it was thought to be desirable to isolate pairs of machines in separate rooms, and similarly to have the Master Control located in a room of its own. However, after considering such factors as sound isolation, personnel supervision, partitions and so on, it was decided to locate all terminal and recording equipment in one area, but to so arrange the layout that partitions could readily be provided later if required. This layout is shown in plan view in Fig. 2.

Fig. 5. Replay Booth.

Seven Ampex VR1000 video tape machines have been installed; six of these were operational for the commencement of the service on July 1st, 1958, the seventh coming into service a few weeks later. Six tape machines are essential for the continuous recording and double replay required to feed approximately fifteen stations on this section of the network. The seventh machine is provided as a standby in case of failure of any of the six in service.

Each video tape machine is provided with both audio and video monitoring facilities. Incoming network, and audio and video test signals are fed to all machines at all times. Pushbutton selection of the desired feed is made at the individual machines.

As received from the manufacturer, much of the equipment was mounted in standard 19-in. equipment racks. In the light of previous experience it was deemed advisable to relocate the equipment in racks specially designed by the CBC engineering staff to provide improved and controlled ventilation of the equipment. Fig. 3 shows a close up of one of the video tape recorders and its associated equipment.

Two telecine chains have been installed, and each chain comprises a vidicon camera, two 16 mm film projectors and a 2 in. x 2 in. slide projector. These chains are intended primarily as a safeguard against network failure anywhere between Toronto and Calgary. Should a failure of an hour or more occur, then both the two hour delay network and the three hour delay network must, each at the appropriate time, be fed with a standby film program. Additionally, an appropriate slide may be inserted in the outgoing feeds to either of the two networks to cover short breaks, programs underrunning, etc.

Special test facilities, shown in Fig. 4, installed at the delay centre include a multiburst Frequency Generator, Window Generator and Stairstep Generator. These signals, together with the familiar Indian Head pattern derived from a monoscope are used for testing both networks.

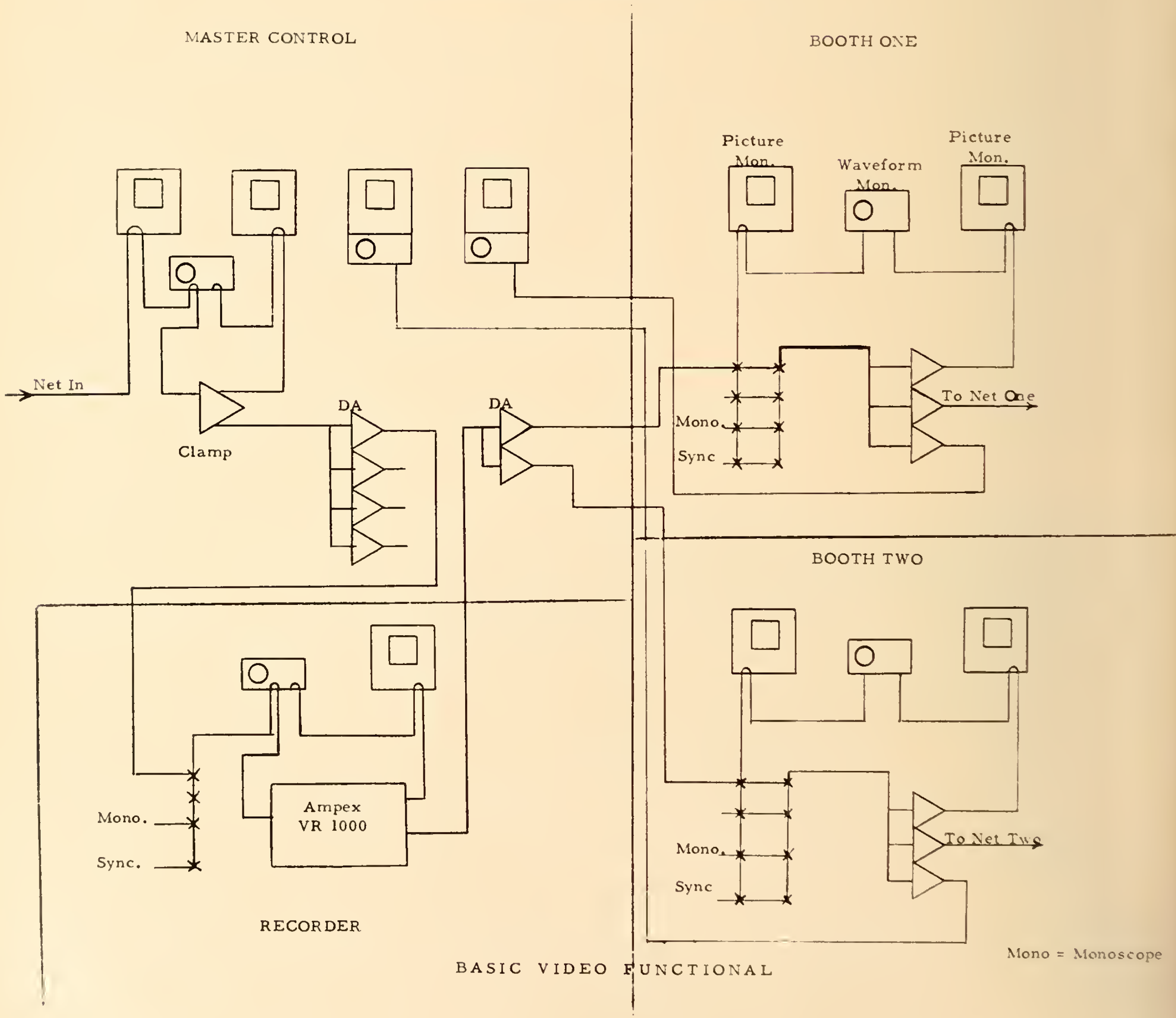
Stabilizing or line clamp amplifiers are available at the Master Control position in order that any degradation of the incoming video signal may be corrected before the signal is fed via distribution amplifiers to the Ampex video tape recorders. Similarly, the audio signals from the network are fed to a line amplifier incorporating a VU meter to permit adjustment of incoming audio signal level.

A high grade picture monitor and a waveform monitor are bridged across the incoming line, which is terminated in the stabilizing amplifier. A picture monitor and a waveform monitor are also fed from the monitoring output of the stabilizing amplifier prior to being fed to the video tape recorders. Picture smearing, for example, may be apparent on signals being received from the network and it is imperative that such a condition be observed and promptly rectified; monitoring both before and after the signal passes through the stabilizing amplifier gives the Master Control operator an immediate clue to the source of such trouble.

Two synchronizing signal generators with changeover facilities have been provided, although their function is of a secondary nature, since the video tape recorders derive their sync pulses from the incoming signal. However, the telecine chains, monoscope and test signal generators require locally generated sync pulses.

Locally generated sync pulses are fed to each video tape recorder to perform two functions. One function is to provide a reference timing signal for accurate replay of the re-

Fig. 6. Functional Diagram of System.



corded programs. Although the 60 cps power line frequency is normally sufficiently accurate for controlling replay speed, occasions have arisen when violent fluctuations of supply frequency in Calgary have caused the tape machines to lose tracking, with consequent disintegration of the picture. For the second function a sync signal is fed to one position of the input selector switch of each tape machine so that on completion of a recording the input may be switched to record only sync pulses for a short period. This ensures that on completion of the replay of a program sync is continued. As an additional safeguard, the sync signal is also fed to the replay booths for switching to the network during station breaks.

Two replay booths are provided adjacent to the Master Control position; these booths have facilities for switching between program sources —i.e. the seven video tape machines, telecine, test signals and sync. Since all the tape machines replay non-synchronous signals, mixing and fading between machines cannot be carried out and it was not, therefore, necessary to provide such facilities in the booths. Simple relay type switches are employed. Each replay booth is equipped with a picture monitor and a waveform monitor for monitoring the outgoing video signal, while a VU meter and loudspeaker provide similar facilities for the audio component of the program. These audio and video monitoring facilities are duplicated for preview purposes. No audio console is provided as each incoming feed to the booth is a complete program fed at the standard level (for video tapes) of + 4 VU and audio selection is accomplished by relay switching, the relays being actuated by a 24 volt supply controlled by additional contacts on the video switcher. By appropriate acoustic treatment the booths have been made suitable for critical subjective monitoring of the outgoing program audio quality, and this is one of the most important functions of the booths. Fig. 5 illustrates the operating position in a booth, showing the equipment installed.

In order to ensure accurate program timing, a crystal oscillator clock unit which delivers a 60 cps frequency has been installed. The secondary clocks are fed from the crystal-derived 60 cps supply via a 30 watt amplifier. A receiver permanently tuned to station WWV, is also installed to provide a constant check on the accuracy of the clock system.

Fig. 7. Master Control Monitoring Facilities.

An office type intercom provides communication between Master Control, the two booths, the seven video tape machines and the two telecine chains. The intercom equipment located in the two booths and at the Master Control position are master stations, the remaining positions being outstations.

System Performance

The video tape machines have been found to meet the manufacturer's specifications adequately, the frequency response being within ±3 db to 2.5 megacycles and approximately 10 db down at 4 megacycles. The low frequency tilt is less than 2%.

The signal to noise ratio of the video recording equipment is approximately 32 db (peak to peak signal to rms noise). Differences in video heads give rise to some variations, with a trend towards receiving quieter heads from the Ampex Corporation as the heads are returned for renewal.

The linearity of the system is adjustable by means of a white stretch circuit incorporated in the processing amplifier. The incoming signal passes through one stabilizing amplifier and one distribution amplifier before being fed to the recorder. On replay the signal passes through but two distribution amplifiers and a relay switcher before being fed back to the microwave network.

The frequency response of the stabilizing amplifiers is essentially flat to 8 megacycles. By the observance of good engineering practices the performance of the system (external to the recorders themselves) is more than adequate to pass the network signal, having a bandwidth of 4.2 megacycles, to the recorder and to feed the replayed signal back to the microwave network without any deterioration beyond that introduced by the recorder. A functional diagram of the video system external to the recorders is shown in Fig. 6.

Audio response is flat within ±3 db from 50 cps to 10,000 cps from network input to network output, including the recording process.

Normal Operation

As mentioned earlier, the Calgary centre delays programs two hours for the Mountain Time Zone, and three hours for the Pacific Time Zone. The signals are received from Toronto over approximately 2000 miles of microwave network and recorded on one of the Ampex machines. Normally, only one half-hour is recorded per machine, following which a second machine takes over for the next half hour. This may seem surprising in view of the fact that an Ampex video tape recorder is capable of recording programs up to one hour in length. A problem, however, is introduced when two replays are required spaced only one hour apart. It will be apparent that, if a one hour reel of tape is used, the beginning of the second replay will approximately coincide with the end of the first replay. Even allowing for the 90 seconds station break, insufficient time is available for rewinding, cueing, etc. before the reel is replayed a second time.

From the foregoing it will be clear that two machines are required for continuous recording and two more for continuous replay. A third pair

(Continued on page 84)

HEAD-LOSS COEFFICIENTS for NIAGARA WATER SUPPLY TUNNELS

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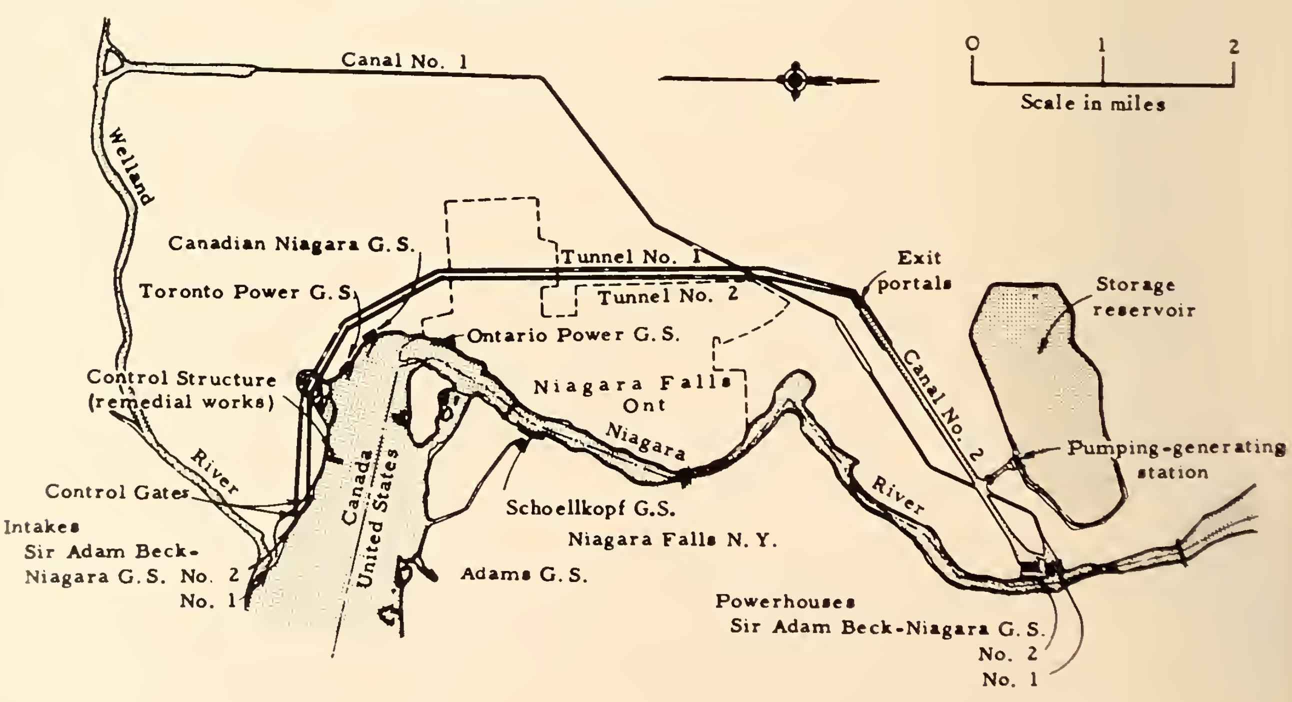
Introduction

Two large tunnels convey the water supply for the Sir Adam Beck-Niagara Generating Station No. 2 from intakes on the Niagara River, some two miles upstream from the falls, to a canal leading to the powerhouse forebay. The tunnels are each approximately 5½ miles long, are concrete lined, and have a finished diameter of 45 ft. During construction 15 piezometer openings were provided in each tunnel to enable tunnel performance, roughness coefficients, and bend loss coefficients to be determined for comparison with design values. The tunnels came into operation in 1954 and a series of field measurements were made to determine the performance of both tunnels. This paper describes the tunnels, the provisions made for field testing, the test procedures, and the results obtained. A comparison with design values is given also.

General Description of Niagara Water Supply System

In Fig. I is shown the general arrangement of the water supply facilities for Ontario Hydro's Sir Adam Beck-Niagara Generating Stations Nos. 1 and 2. The original supply facilities for the Sir Adam Beck-Niagara Generating Station No. 1 (formerly known as the Queenston Development) consisted of an intake on the Niagara River at the juncture with the Welland River, and an open power canal, designated canal No. 1, leading from the Welland River to the generating station. A maximum diversion in excess of 15,000 cfs is carried by this canal system. The

Fig. 1. General plan of Niagara water supply system.



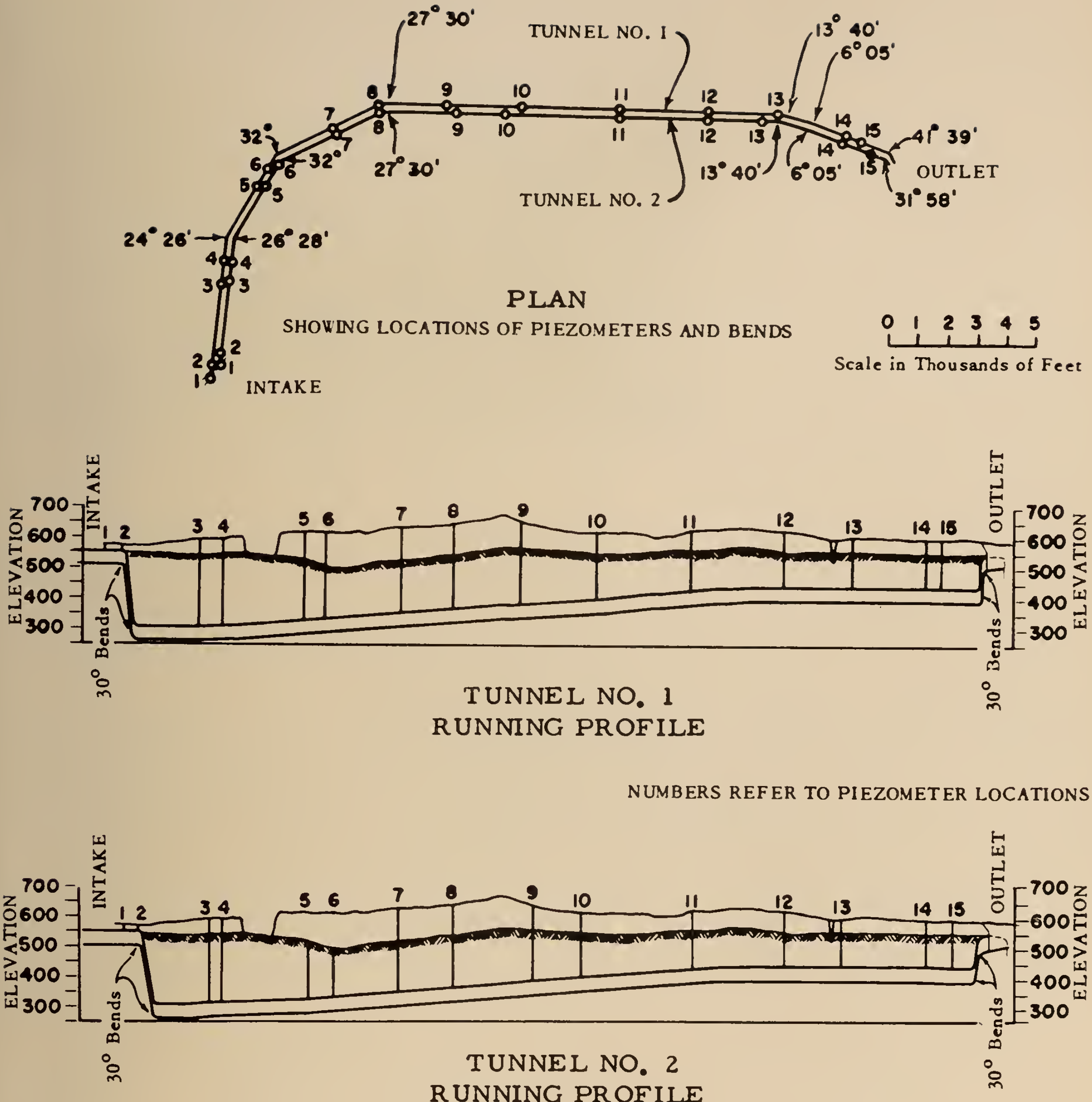


Fig. 2. Plan and running profile of tunnels showing Piezometer locations.

passage of the 1950 treaty between Canada and the United States made possible a redevelopment of Niagara Falls, and the Sir Adam Beck-Niagara Generating Station No. 2 was constructed adjacent to the No. 1 station.

The water supply for the new development is obtained from the Niagara River through two submerged gathering tube intakes located some two miles upstream from the falls and downstream from the original intake at the Welland River. After leaving the intakes, the water supply is conveyed approximately 5½ miles by two large tunnels which discharge through an outlet structure at their downstream ends into an open canal, canal No. 2, which conveys the flow about 2¼ miles to the No. 2 plant forebay. Canal No. 2 crosses the original power canal at the same grade and water level about ¾ of a mile upstream from the forebay, and both forebays are interconnected near their downstream ends. The pump storage plant draws its water supply from canal No. 2 just upstream from the canal crossover. The new water supply facilities can divert a maximum of about 48,000 cfs.

Description of Tunnels

The tunnels were driven through rock at a bore of 51 ft. and were lined with concrete to a finished diameter of 45 ft. The tunnels are parallel to each other on 250 ft. centres, and the geological formation of the area required that the tunnels be generally about 250 ft. below the surface. Tunnel No. 1 which follows the outer course of the river is about 28,800 ft. long, and tunnel No. 2 which follows the inner course is about 28,100 ft. long. In Fig. 2 is shown a plan and running profile of the tunnels.

The alignment of the tunnels required 11 bends in tunnel No. 1 and 10 bends in tunnel No. 2. The one bend less in tunnel No. 2 was due to the ability to combine one horizontal and one vertical bend into one composite bend near the outlet. Based on preliminary experimental work, an R D ratio (radius of curvature to diameter) of 5 was selected for each bend to minimize losses. The locations and deflection angles of the bends included between piezometers are given in Tables I and II.

The concrete lining for the tunnels was poured in two stages, the invert and the arch. The invert portion, forming the bottom segment of 60°, was shaped by a steel screed, wood floated, and steel trowel finished by hand. The arch, which constituted the remaining 300°, was made in one continuous pour around retractable, movable, oiled steel forms, 50 to 85 ft. long. Joints between adjacent pours were first sawn to a ¾ in. width and then filled with a quick setting cement mortar, and any projecting circumferential edges were ground to a 45° bevel. In Fig. 3 is shown a photograph of a portion of tunnel No. 2 with the lining complete.

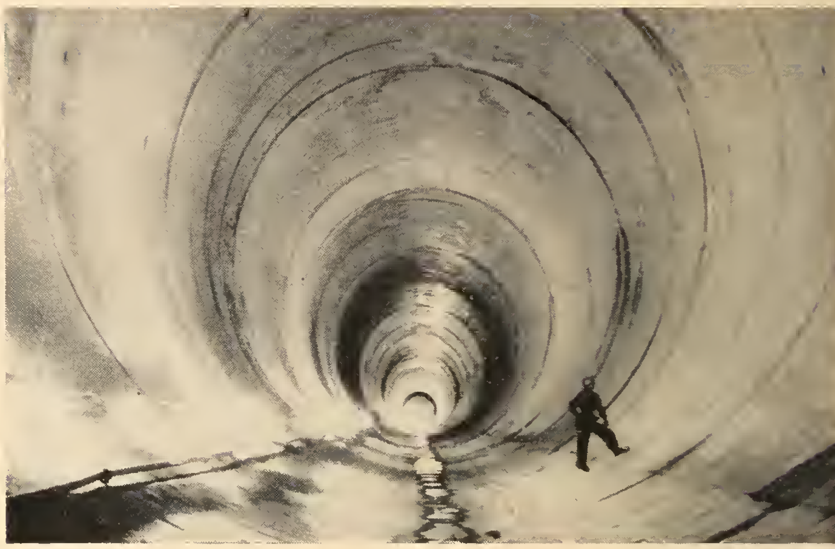


Fig. 3. Interior view of 45 ft. diameter Niagara tunnel No. 2 near downstream end with concrete lining complete.

Design Considerations

In the design of large water supply tunnels such as those provided at Niagara, an accurate knowledge of the roughness coefficients and the bend loss coefficients is of the utmost importance. For a particular flow capacity, the size of the tunnels depends upon the coefficients selected, and the accuracy of the selection governs whether or not the expected flow capacity will be realized. In selecting the roughness coefficient for the Niagara tunnels, it was found that very little data was available on tunnels of these dimensions. A formula proposed by Mr. F. C. Scobey, Consulting Engineer, which was based on an analysis of many tunnels, was considered most applicable and was used for the design.

It was found also that very little comprehensive bend loss information was available for large tunnels. As the alignment of the tunnels was such that a relatively large number of bends was necessary, it was considered that reliable information was required to determine the R D ratio for the bends that would produce a minimum head loss, and to determine the bend loss coefficients themselves. Accordingly, comprehensive experiments were carried out on a 6 in. pipe to determine bend loss coefficients for a range of R D values and deflection angles, and in Fig. 5 the results of these experiments are shown. While it was expected, due to the scale factor, that the bend loss coefficients in a 45 ft. tunnel would be somewhat less than those in a 6 in. pipe, it was felt that the results would be relative and would provide comprehensive and conservative values for design.

Due to the lack of field data on losses in large tunnels, it was felt very desirable to provide permanent means of measuring the losses in the completed tunnels. This would enable the performance of the tunnels to be determined, the loss coefficients to be checked, and would provide a means of detecting any change in performance over a period of time. Accordingly, provision was made for such measurements.

Table I
Locations of Piezometers and Included Bends

Tunnel No. 1

Piezometer No.	*Tunnel Chainage (horizontal) feet*	*Centre Line Distance between Piezometers feet*	*Bends, Radius 225 Ft.* Deflection Angle	*Bends, Radius 225 Ft.* Chainage of P.I. feet
1	47 + 62			
		537		
2	52 + 99			
		2,668	2 @ 30°	53 + 67 57 + 91
3	79 + 07			
		782		
4	86 + 89			
		2,696	24° − 26′	95 + 28
5	113 + 87			
		671		
6	120 + 58			
		2,553	32° − 0′	126 + 34
7	146 + 14			
		1,718		
8	163 + 32			
		2,241	27° 31′	166 + 16
9	185 + 75			
		2,512		
10	210 + 87			
		3,148		
11	242 + 35			
		3,094		
12	273 + 29			
		2,290		
13	296 + 19			
		2,454	13° 41′ 6° 06′	297 + 91 309 + 53
14	320 + 73			
		516		
15	325 + 89			

Provision for Field Testing

During construction of the tunnels, 12 in. diameter holes were drilled from the ground surface to the tunnels at approximately 500 ft. intervals along the centre line of each tunnel and were lined with 10 in. diameter steel pipes. These holes, which were used to supply concrete for the tunnel lining, offered an excellent opportunity for the measurement of pressure head in the tunnels. It was decided to convert 26 of these holes, 13 in each tunnel, into piezometer wells. In addition 4 piezometer wells, 2 in each tunnel, were installed near the inlet ends. The locations were chosen such that the pressure head could be measured, insofar as possible, at approximately 40 diameters downstream from each bend, 5 diameters upstream from each bend, and at selected points on the long straight section of each tunnel. The locations of these piezometer wells are shown in Fig. 2, and the details of a typical piezometer installation in Fig. 4. While it was recognized that a piezometer ring would have been superior at each point, the considerable number of necessarily more complex installations were not considered to be practicable.

Table II
Locations of Piezometers and Included Bends

Tunnel No. 2

Piezometer No.	*Tunnel Chainage (horizontal) feet*	*Centre Line Distance between Piezometers feet*	*Bends, Radius 225 Ft.*	
			Deflection Angle	*Chainage of P.I. feet*
1	54 + 26			
		522		
2	59 + 48			
		2,409	2 @ 30°	60 + 27 64 + 50
3	82 + 98			
		391		
4	86 + 89			
		2,861	26° – 27′	95 + 78
5	115 + 52			
		827		
6	123 + 79			
		2,136	32° – 0′	125 + 62
7	145 + 18			
		1,773		
8	162 + 91			
		2,657	27° – 31′	166 + 77
9	189 + 50			
		1,590		
10	205 + 40			
		3,695		
11	242 + 35			
		3,095		
12	273 + 30			
		1,861		
13	291 + 91			
		2,859	13° – 41′ 6° – 6′	298 + 21 307 + 09
14	320 + 50			
		891		
15	329 + 41			

Description of Testing Equipment

To determine the pressure head at each piezometer, special gauges were constructed to measure the vertical distance from the top of the 10 in. well pipe to the water surface in the well. A weight, suspended on graduated insulated conductor cables, was lowered from the top of the well to the water surface. From the bottom of the weight extended two electrical contacts which completed a circuit when they touched the water surface. An ammeter and battery at the ground surface completed the equipment, the ammeter indicating when the contacts touched the water surface. The elevations of the tops of the well pipes were carefully determined by precise levelling from project bench marks.

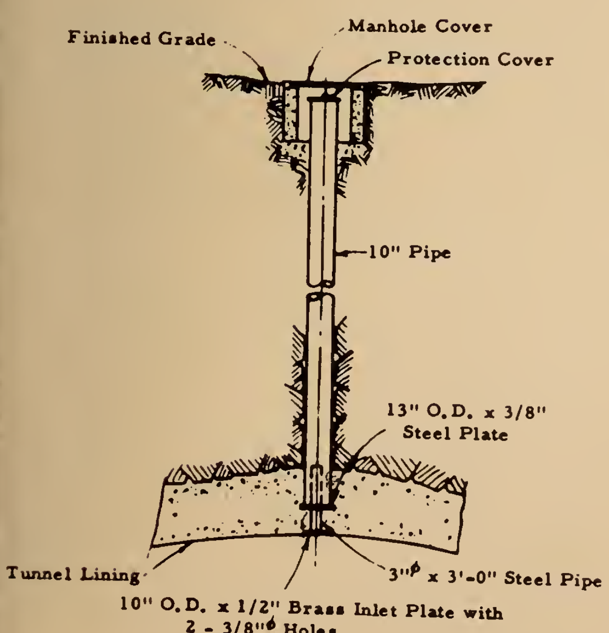


Fig. 4. Details of Piezometer installations.

Test Procedure

In June of 1954 the No. 1 tunnel came into service, and during September and October of that year 5 tests were made on the tunnel at discharges ranging from 13,350 cfs to 24,050 cfs. The test procedure used was to stabilize first the plant forebay level which governed the discharge through the tunnel. When steady conditions had been achieved, measurements of water level in all the piezometer wells were made, and the discharge through the tunnel was measured by current meter in the canal downstream from the tunnel. Each test was of approximately 3 hours' duration, the time necessary to make the current meter measurement. Water levels in the piezometer wells were measured at 5-minute intervals. Using the data obtained in these tests, a discharge calibration of the No. 1 tunnel was obtained by plotting the measured discharges against the measured fall between piezometers 2 and 13. The results of this plot are shown in Fig. 6, where the consistent nature of the relationship between discharge and fall may be noted. It is considered that this relationship provides a sensitive and

Table III
Summary of Data Obtained During Tests

	Tunnel No. 1						Tunnel No. 2
Test Number	1	2	3	4	5	6	7
Date	Sept. 18/54	Sept. 18/54	Sept. 19/54	Oct. 15/54	Oct. 16/54	Nov. 24/55	Nov. 24/55
Discharge cfs	18,010	15,990	13,345	24,050	20,800	23,110	23,110*
Water Surface Elevation							
Piezometer							
No. 2	558.49	559.33	560.28	556.66	558.43	557.05	556.43
3	556.93	558.03	559.25	554.35	556.48	555.08	554.73
4	—	—	—	—	—	—	—
5	555.59	556.99	558.48	552.13	554.79	552.95	552.73
6	555.37	556.83	558.37	551.71	554.46	—	—
7	554.56	556.24	557.92	550.36	553.33	551.18	550.80
8	553.97	555.76	557.61	549.25	552.50	550.21	—
9	—	—	—	—	—	—	548.56
10	552.34	554.49	556.70	—	—	547.39	—
11	551.27	553.69	556.12	544.55	548.80	545.71	545.53
12	—	—	—	—	—	544.08	543.79
13	549.48	552.29	555.15	541.48	546.37	542.73	542.74
14	548.65	551.68	554.78	540.07	545.16	—	—
15	—	—	—	—	—	—	540.41
Water Temp.—°F	63	63	64	61	57	44	44

* Estimated.

Table IV
Computation of Roughness Coefficients

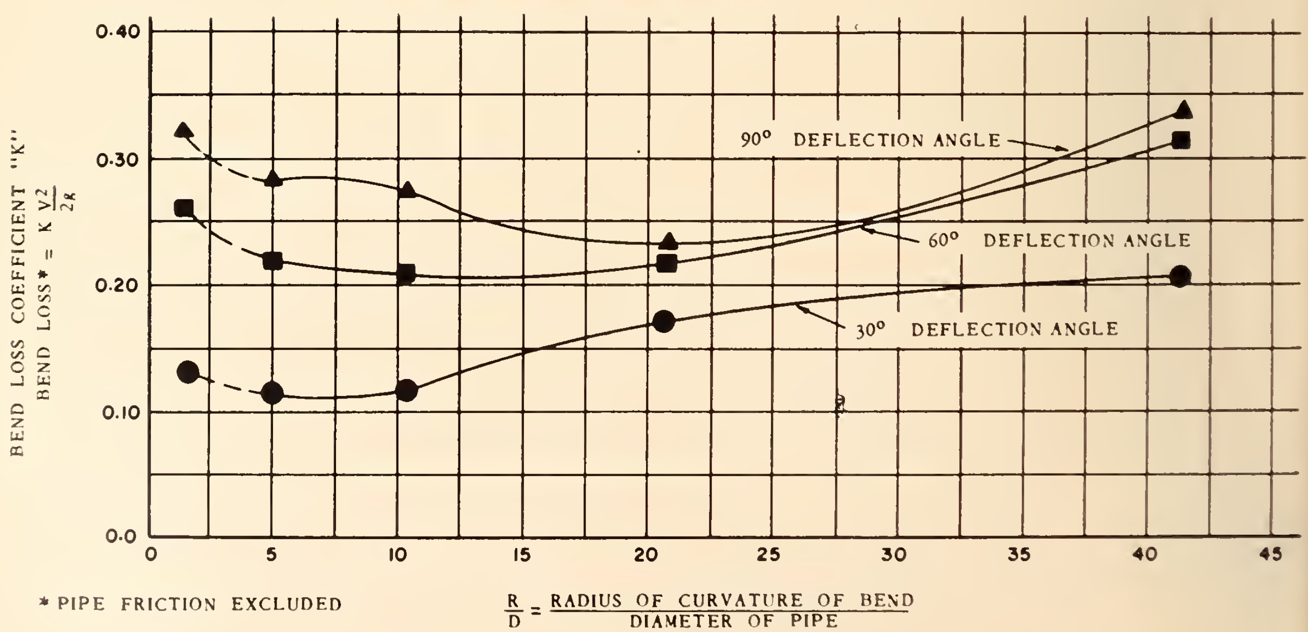
Test No.	*Tunnel No.*	*Discharge cfs*	*Velocity fps*	*Reynold's Number*	*Average Head Loss Feet Per Thousand*	*Manning's n*	*Weisbach f*
1	1	18,010	11.33	4.35×10^7	.336	.0121	.00759
2	1	15,990	10.05	3.87×10^7	.260	.0120	.00746
3	1	13,345	8.39	3.25×10^7	.180	.0119	.00742
4	1	24,050	15.12	5.66×10^7	.592	.0120	.00750
5	1	20,800	13.08	4.60×10^7	.462	.0123	.00782
6	1	23,110	14.53	4.16×10^7	.549	.0120	.00754
7	2	23,110*	14.53*	4.16×10^7*	.568	.0122*	.00780*

* Estimated.

satisfactory meter of the No. 1 tunnel flow.

Tunnel No. 2 came into service during October 1954, and a test with both tunnels in operation was made in November 1955. Sufficient gauges were not available to measure the water levels simultaneously in the piezometer wells of both tunnels. Accordingly, measurements were made first on tunnel No. 1 at 5-minute intervals for 2 hours, and then similar measurements were made on tunnel No. 2 for an equal period. It was planned that during the test the discharge through both tunnels would be measured by current meter in the No. 2 canal downstream from the

Fig. 5. Bend loss coefficient curves from tests on a 6 in. steel pipe.



tunnels. The No. 1 tunnel discharge would be then determined from the fall-discharge relationship obtained in the No. 1 tunnel tests, Fig. 6, and the No. 2 tunnel flow by subtraction. Unfortunately it was found that with both tunnels in operation at the low forebay level, the velocities in the downstream canal were too high for accurate current metering. A secondary method of obtaining the discharge, that of metering the No. 1 canal flow and subtracting it from the total plant discharge, also proved unsatisfactory, as velocities in the No. 1 canal were again too high for accurate current metering. Therefore, no accurate measurement of the No. 2 tunnel flow was obtained. From the approximate measurements that were made, it appeared that the No. 2 tunnel was carrying about the same flow as the No. 1 tunnel. Based on the assumption of equal flows in both tunnels, results have been computed for the No. 2 tunnel for comparative purposes, but these must be con-

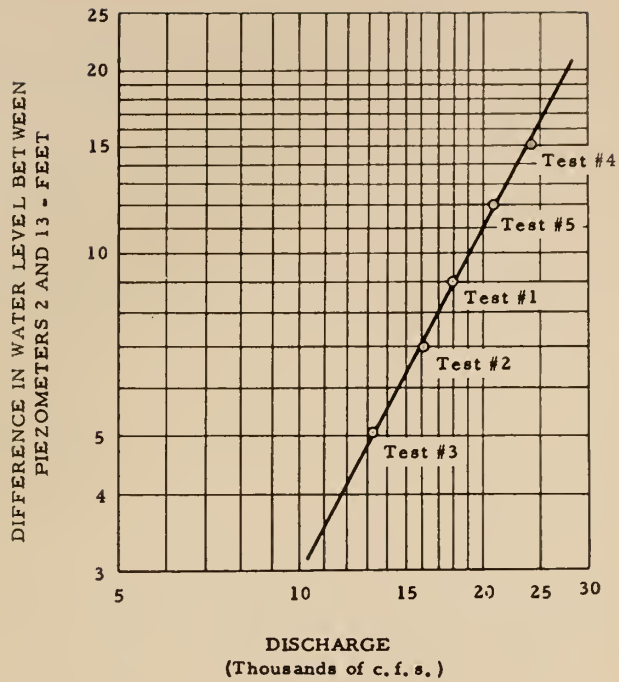


Fig. 6. Tunnel No. 1, relation between head drops, Piezometers 2-13, and discharge.

Fig. 7. Relative roughness of Niagara tunnels.

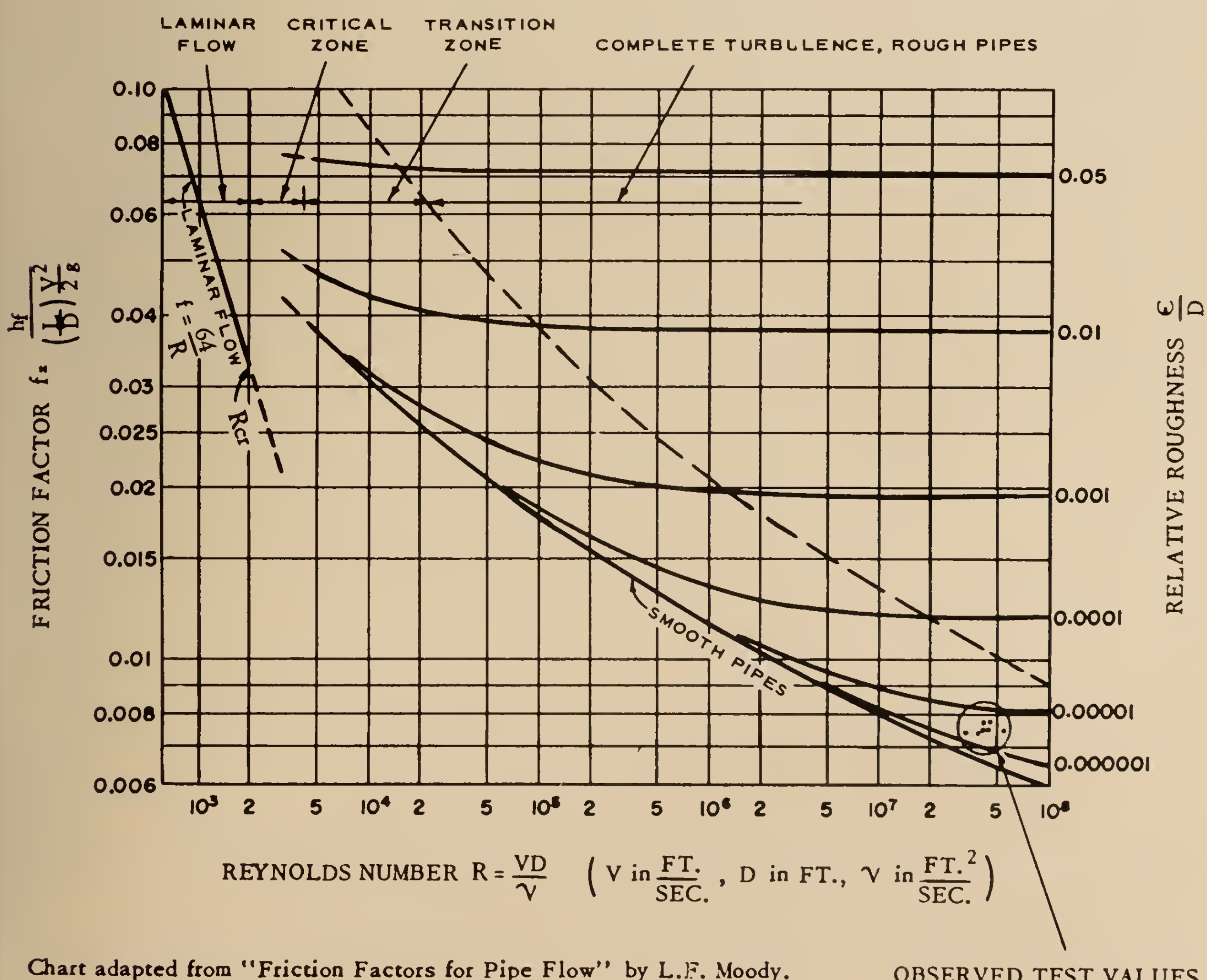


Chart adapted from "Friction Factors for Pipe Flow" by L.F. Moody. *A.S.M.E. Transactions*, vol. 66, no. 8, November, 1944, page 671.

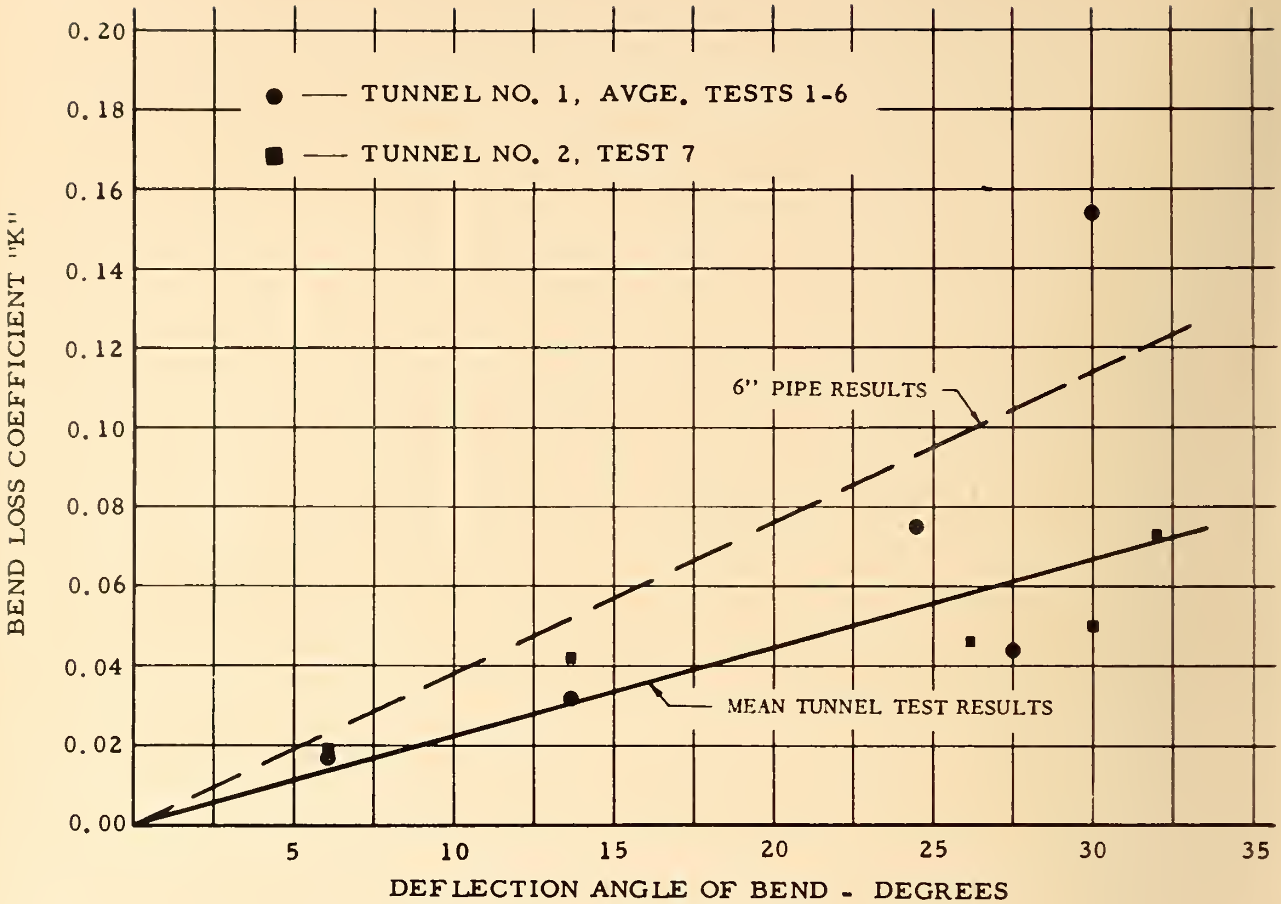


Fig. 8. Results of bend loss tests.

sidered as estimates only.

Method of Computing Head Loss Coefficients

The tunnel gauges were so located that 3 reaches did not contain bends and were considered sufficiently downstream from the preceding bend to permit true friction losses to be obtained. Insofar as possible all these reaches were used in the computation of roughness coefficients. For each test the average water surface elevation in each piezometer well and the head loss between wells were determined. The average head loss per thousand feet was computed from the total head loss and the total length between piezometers in the straight sections. Computations were then made for each test of the roughness coefficient n in the Manning formula:

$$V = \frac{1.486 r^{2/3} s^{1/2}}{n}$$

and the roughness coefficient f in the Weisbach formula:

$$h_f = f \frac{L}{D} \frac{V^2}{2g}$$

where:

V = average tunnel velocity in ft. per second.

r = hydraulic radius of tunnel in ft.

s = mean slope of hydraulic gradient.

h_f = loss in head due to friction in ft.

L = length of tunnel reach in ft.

D = diameter of tunnel in ft.

g = acceleration due to gravity in ft. per second per second.

For each test, using the roughness coefficients determined from the straight sections, the friction loss between piezometers in the reaches containing bends was computed, and the bend loss determined by subtracting this friction loss from the measured total head loss between piezometers. For each bend loss thus obtained, computations were made of the bend loss coefficient K in the formula:

$$h_b = K \frac{V^2}{2g}$$

where; h_b is the head loss in feet due to the bend only.

Test Results

In Table III is summarized all the measured data obtained during the tests on the tunnels. The levels for piezometer No. 1 are not included in the table as this piezometer is located near the outlet from the intake and is not relevant to these tests. When the tests were carried out it was found that certain of the piezometers were plugged or partially plugged and were obviously not yielding the correct water level, and these also have been omitted from the tabulation.

The results of the roughness coefficient computations appear in Table IV where the values of n and f are given for each of the tests. Tabulated also for each test are the tunnel discharge and velocity, the average friction loss per thousand feet, and the Reynolds Number. In Fig. 7 the values of f obtained from the tests are plotted on a Reynolds Number base on the chart adapted from *Friction Factors for Pipe Flow* by L. F. Moody, A.S.M.E. Transactions, November 1944. The purpose of this plot is to compare the roughness of the Niagara tunnels with that to be expected from theoretically smooth pipes, and to indicate the relative roughness of the tunnels.

For tunnel No. 1 the average value of n obtained for all the tests was 0.0120. Although the Scobey formula was not similar in form to the Manning formula, the predicted losses for the test conditions would produce an

(Continued on page 85)

THE USE OF ELECTRONIC COMPUTERS IN THE FIELD OF CIVIL AND STRUCTURAL ENGINEERING

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The rapid development of the use of electronic computers in the field of civil and structural engineering has been one of the most fascinating developments in recent years. The progress has been such that it has become important that engineers review their methods and approach to problems in the light of the possibilities inherent in this new tool.

Aided by our public newspapers and popular magazines, we have tended to accept in the past the stereotyped concept that the electronic computer can only be operated by experienced scientists, mathematicians or physicists, and could be applied to only the most complex of problems. In truth such concepts are far from reality and retard the practical application of these modern tools to everyday problems.

The main purpose of this paper is to show how the electronic computer can, in fact, be applied to the most common and prosaic of tasks.

Let us begin by putting the computer in its proper place in relation to the engineer. In his excellent book on this subject, Mr. MacCracken of the General Electric Co. made the observation that the computer should not be regarded as an electronic brain but rather as a high-speed moron. This emphasizes the main point that the computer is the servant, not the master. It has to be told, it cannot tell. It bears the same relationship to the engineer as does the slide-rule, the desk calculator, the transit, and the aerial photograph. These are all means by the proper and judicious use of which the engineer can better and more efficiently perform his tasks.

Section I—Basic principles

It is necessary to understand the fundamental principle of computer operation in order to fully appreciate the applications of this tool. A short introduction is therefore necessary for the benefit of readers not familiar with these fundamentals.

The computer is essentially a piece of equipment capable of adding, subtracting, multiplying, dividing, and storing information. The operations are carried out automatically in accordance with a set of instructions given it beforehand. A commonly used analogy is the post office analogy. The procedure can be likened in a rather crude fashion to a post office sorting room. Fig. 1 shows a sketch of such a room together with the corresponding computer diagram. On the right is a set of pigeon-holes in which are located data or other information. On the left is an instruction board on which are listed in precise detail the instructions to be followed by the postal clerk. In the middle is a table on which the clerk can perform the tasks assigned to him.

The pigeon-holes are all numbered. These numbers are called, naturally enough, addresses. The first instruction may tell the clerk to clear the table. The second tells him to go to slot no. 1 and to add the contents to what is on the table. He does this by going to the slot, copying what is in it, and taking this information to the table. Since the table is clear, the information on the table is now the same as that contained in slot no. 1.

The third instruction tells him to go to slot no. 2 and add the information to the table. This is done as before and now, since the table previously contained the information in slot no. 1, it now contains the sum of the information in slots no. 1 and no. 2.

The fourth instruction tells him to take the answer from the table and store it in slot no. 3. The last instruction tells him to stop. This is necessary, since, in the case of the computer, the operating medium is unable to make any decisions on its own and would become either very confused or very worn out searching for a non-existent instruction.

The operation of the computer is similar. However, the instructions are carried out at speeds almost beyond our comprehension. The speed of different equipment varies from about 200 operations per minute for the smaller slow-speed equipment to 40,000 operations per second for very high-speed equipment.

Section II—Vocabulary

A certain addition to our regular engineering vocabulary is necessary to enable us to discuss computer applications in simple terms.

The words *accumulator*, *memory* or *control* are readily understood from Fig. 1. The accumulator is obviously a place where the actual numerical operations are carried out by means of accumulating the information. The memory is, of course, where numbers are stored until required. The control directs the operation. The address is the number which locates the slot in the memory. The memory may consist of magnetic drums, cores or tapes. Some portions of the memory may be easier to reach or faster in use than others. Such portions are referred to as *high-speed memories* or *immediate access memories*. Other portions of the memory may be quite slow to use and are not so readily accessible. These are called *remote or secondary memories*.

The instructions given to the control are called the *program*. The operation of feeding the *program* into the machine is called *program input*. This is the means by which the machine is activated to work on an actual problem.

The data may be fed into the machine by means of punched tape, punched cards, magnetic tape, or it may be typed directly by means of an operator. This whole phase of the operation is called *input*.

Correspondingly, the means by which the machine released the information computed by it is called *output*. Often the machine can compute far faster than it can get rid of the information it has computed. In such a case the problem is *output limited*.

Some may wonder about the terms *digital* and *analog*. The computers described in this paper are all digital computers. They operate on the basis of numbers of digits. Analog computers operate on the basis of analogous circuits or measurements (i.e. slide-rule) and results are measured in physical terms from such circuits, i.e. voltage drops. A typical analog computer operation is a network analyser, such as used by many power authorities to determine network properties.

Fig. 2 shows a typical analog computer. Note its size and the board by which the properties of the internal circuit can be adjusted.

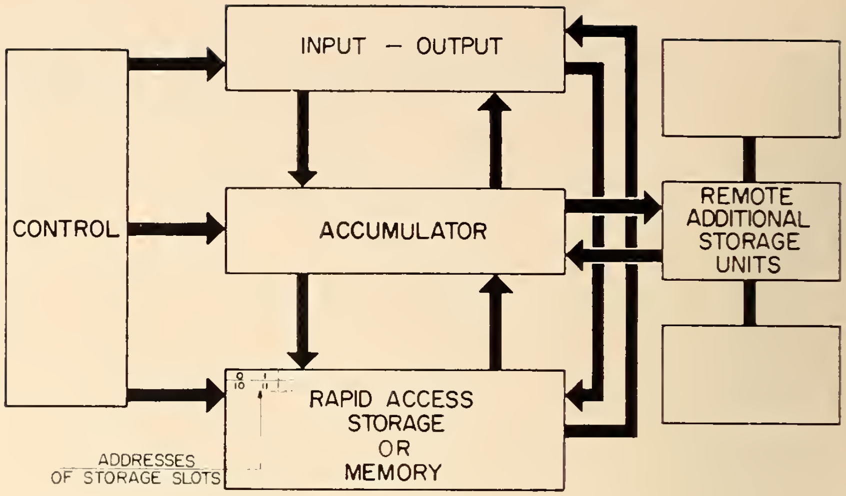


Fig. 1. Sketch showing post office "analogy".

Fig. 3 shows a typical digital computer. This computer is an IBM 650, a medium-speed computer operating at about 2400 operations per second. (0.67 ms add 12-17 ns X ÷)

Fig. 4—a slow-speed digital computer—Burroughs Electrodata 101.

Fig. 5—Univac II, a high-speed digital computer.

Fig. 6—IBM 704—a very high-speed digital computer.

Fig. 7 — Bendix G-15-D — a medium-speed computer.

Fig. 8—LGP 30—Royal McBee.

All digital computers operate on the same basic principles. Therefore, while the mode of operation of each machine may differ, the philosophy behind their use remains constant.

The balance of this paper is concerned with the program itself or, in other words, the instructions given to the machine for the execution of a particular series of operations for a given problem.

Section III—Civil Engineering Applications

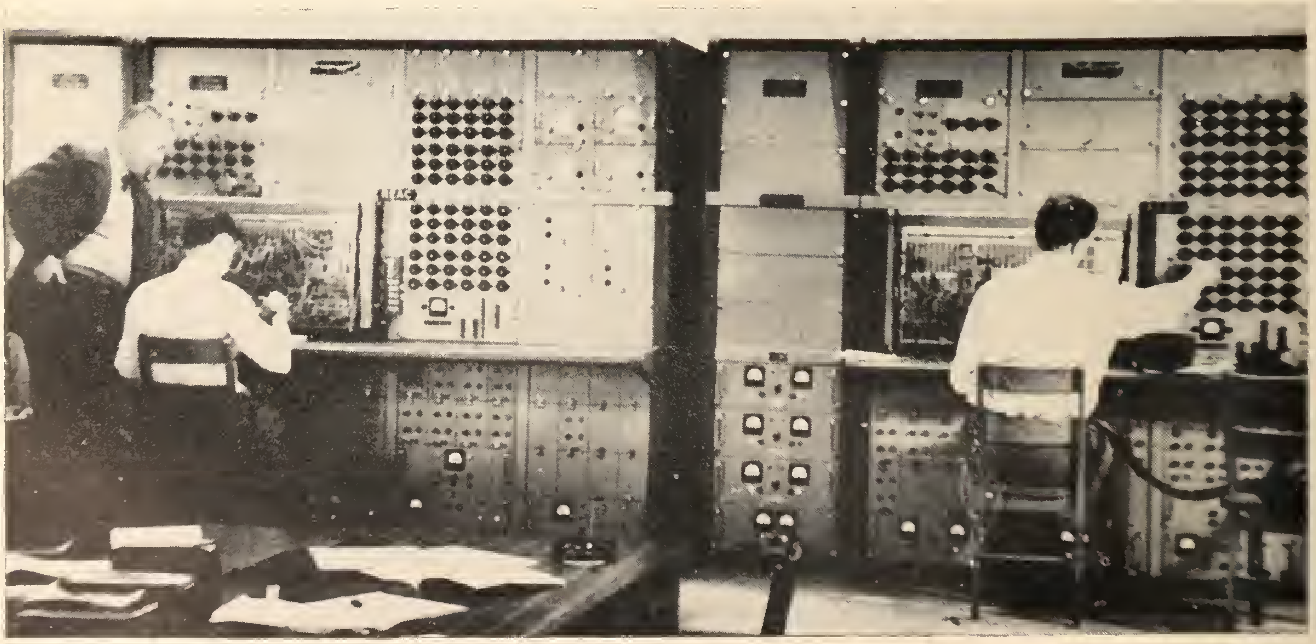
The three major fields of application in civil engineering are:

a) Earthwork
b) Structures
c) Hydraulics and Hydrology

a) Earthwork

The application of electronic computers to earthwork computations is probably the most widespread application to date. In this field the com-

Fig. 2. Typical Analog Computer (REAC).



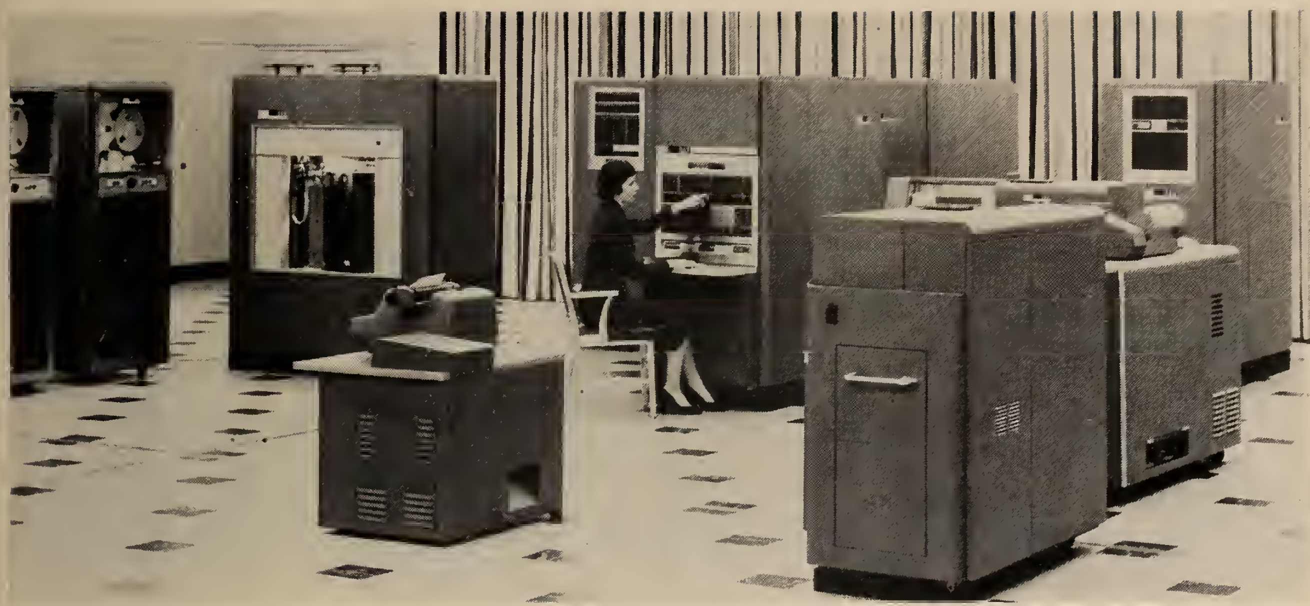


Fig. 3. I.B.M. 650 Computer.

puter has shown itself capable of performing in a few hours work which normally would have taken several men several weeks or months. The simplest application is, of course, the straight volume calculation, such as used on highways or for borrow pits. In these applications the computer is used to rapidly determine the volumes of earth that have been moved or that would be moved in accordance with a certain plan.

This is, of course, one of the earliest applications of the computer in the civil field. However, a more sophisticated use of the computer has begun to develop. As an example of this we may cite highway earthwork quantities. At first, the original cross-sections and the profile and template of the finished roadway were fed in as data into the computer. The computer then calculated the quantities of cut and fill material required for a certain stretch of road. It also could calculate the accumulated difference or the mass-haul diagram.

The computations are so rapid that it becomes soon apparent that one bottleneck is the mere handling of data. Problems very frequently become limited by input capacity and the time required to place the data into the computer becomes by far the largest part of the computation time. This, of course, is a most inefficient way to use high-priced equipment. Therefore, the idea has been conceived of marrying the electronic computer with aerial photography, and this has been done most successfully in at least two or three instances. One such program developed by a firm called Photronix, Inc. of Columbus, Ohio, determines from the aerial photographs the cross-sections of the road. The stereo-plotter transforms automatically the data into a form suitable for acceptance by a computer. In this manner, the amount of work required in data input is minimized. This procedure is also followed by McElhanney, McRae, Smith & Nash of Vancouver, B.C.

This is one of the most interesting consequences of the advent of electronic computers. Engineers are apparently not satisfied with merely being relieved of the drudgery of carrying out computations. They immediately set about to find additional work for themselves to do. As a result, they produce computer programs which do far more than could have been possible manually. They devise means whereby they not only determine the volumes of cut and fill and the excess of one or the other over a certain stretch of road, but, in addition, they have developed means which will automatically balance volumes of cut and fill by profile adjustment. The final end result is therefore the optimum grade calculated electronically directly from aerial photography. The accuracy of such results is better than 1%, a figure consistently achieved in Ohio and Indiana. This has been so successful that contractors have begun to quote better prices on computer calculated quantities than on manually computed quantities since they have found them to be more reliable. This reliability is, in fact, one of the major advantages of the computer. Once a program is established and is checked out for a given problem, we can be sure that the results produced by that program will be accurate. The element of human error is at least minimized, if not completely eliminated.

The Ohio program mentioned previously selects the optimum vertical alignment on a given horizontal alignment for a given highway. It will do this for either single or dual lane roads. It will even vary the vertical alignment in each individual lane in order to produce optimum conditions.

The Massachusetts Institute of Technology has developed a computer program which not only determines optimum vertical alignment but also selects optimum horizontal alignment. This is done from aerial photography using a grid of elevations taken over a given terrain. In this case the electronic computer is used not only to select the optimum vertical elevation, but also the optimum horizontal routing to produce the most economical overall route considering physical terrain conditions only.

At this point the engineer's new role becomes apparent. In the past he has been often used in operations involving considerable amounts of drudgery, thus occasioning a considerable waste of talent and manpower. In his new role, however, he will not have to make monotonous calculations but he is going to have to be most careful that the results achieved by the computer have real meaning. He must assess factors not included in the data supplied the computer, see whether they can be or should be considered by it, and make allowances for such considerations in his interpretations. The engineer must be careful not to accept computations for more than what they are, namely additional data on which he can make a considered engineering judgment. He must make sure that the necessary social elements, such as the routing of the highway through suitable areas, are taken care of. He must make sure that the information being fed to the computer is not based on invalid assumptions. He must make sure, in other words, that the answer is not only correct from the mathematical point of view, but also correct from other engineering and social-political aspects. Some of these aspects and different points of view can be themselves expressed in the form of a program and given to the machine itself. In other words, in the MIT program it would be quite possible to limit the possible road locations and to weigh the cost of obtaining access rights, etc. It is possible to feed in terrain data, such as whether the ground is rock, muskeg, clay or sand. Naturally, as the problem becomes more and more complex, it is going to be necessary for the engineer to pay far more attention to the validity of his basic assumptions in relationship to the problem under study.

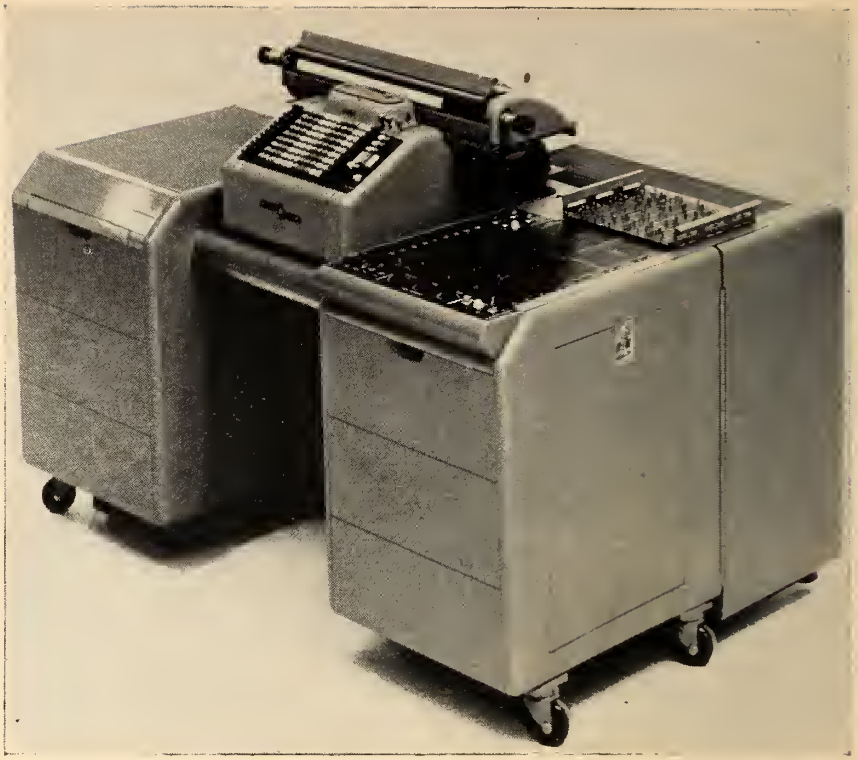


Fig. 4. Burroughs Electrodata 101.

Questions have been raised about the validity of old and standard approaches to some problems. For instance, are we really achieving minimum cost by balancing cut and fill or by balancing cut and fill modified by material factors? Is it not actually the fact that the fill and the cut material themselves, except that taken from a borrow pit under royalties, costs nothing? It is the cost of excavation, transportation, back filling, and compacting that involves the expenditures. Therefore, is it not better to analyse the design of a road in terms of the means by which that road is going to be constructed? We know that hauling material uphill is more costly than hauling material downhill. We know that certain types of material and excavating equipment cannot operate at the same speed or with the same capacity as others. The conditions of the ground over which the equipment works is also of importance and can be made a part of our cost considerations.

There is a term that is useful in discussing computer application, and that is *mathematical model.* This word is self-explanatory and represents a wholly mathematical reproduction of a particular problem. On such a model we can perform operations, we can study the effects of certain variables, and we can make

Fig. 5. Univac II—High Speed data processing Computer.

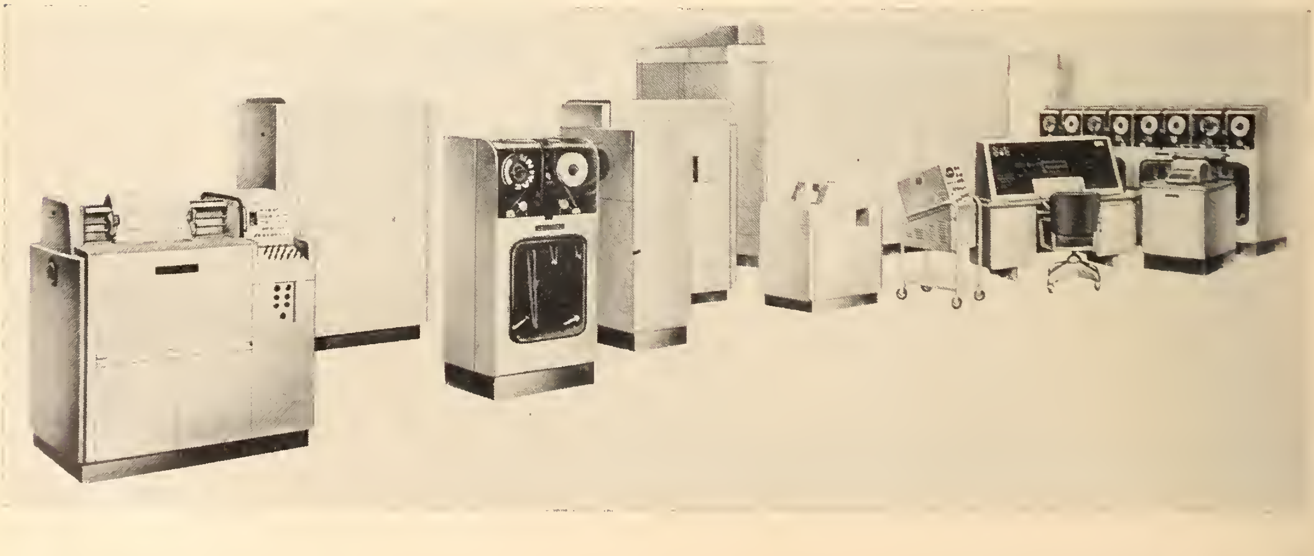


Fig. 6. I.B.M. 704 High Speed Scientific Computer.

a complete re-study of cost. The main advantage of such a model is that it can be altered readily and that the cost of production of the model, provided that it falls within a certain general pattern, is usually trivial.

b) Applications to Structures

The application of the electronic computer to structures is somewhat of a paradox. In a particular sense, probably no field of computer applications has been as thoroughly studied and as thoroughly developed as the structural application field. The aircraft industry has made use of electronic computers for structural computations for several years and stress analysis has become a major function for the computers in the aircraft field. We mentioned the word paradox because insofar as civil engineering is concerned, there has been little use made of computers to date. There appears to have been very little migration of information between the two fields. This is due in part to the fact that in the aircraft industry the computations carried out have been of such complexity that manual operations were out of question. Therefore it became quite natural to turn to the electronic computer, since the initial cost of solutions was not a major consideration. The relationship of weight to strength bears a very much greater importance in the aircraft field than it has in the past in the structural field. Therefore, the need and the essential requirement is for thorough analysis.

In structural design the cost of program development cannot usually be amortized on a given operation. It is therefore necessary to reuse a program several time to justify its existence. Medium-speed computers have now reduced programming costs albeit at the expense of slightly higher operating expenses.

With the increasing availability of medium-speed computers in the lower cost ranges and increasing familiarity of engineers with the potential of the computers, rapid progress is beginning to be made in this field. Later on in this paper we will discuss in detail a particular application of electronic computer to the design of a multiple rigid frame.

c) Hydraulics and Hydrology

The electronic computer has been used successfully for years by such organizations as the Ontario Hydro and the US Corps of Engineers for hydraulics and hydrologic calculations. The computer with its high speed is well adapted to the tedious and repetitive calculations that are associated with several hydraulic calculations, such as open channel flow and surge tank calculations.

The application of the electronic computer to the field of hydrology is beginning to be more widespread. In particular, the US Corps of Engineers has made successful application of electronic computers to hydrographs, water reservoir flows, and flood control problems in general. It is now quite feasible to develop a mathematical model of a watershed and to investigate very thoroughly in a pre-hydraulic model stage, if you wish to call it that, the possible effects on a watershed of certain improvements.

Finally, we have the application to general miscellaneous items, such as surveying, planning coordination, estimating traffic analysis, etc. In this field the computer has been successfully applied to asimuth observations, geodetic calculations, closure of traverses, layout of highway slope stakes, layout of interchange ramps, layout of curves, etc.

It can also be used in overall planning, scheduling, and coordination of projects. In other words, the entire schedule of a project of a civil engineering nature can be put on to a computer and various combinations of timing for various phases of the work can be studied in relationship to their effect on overall cost. And in similar fashion the computer can be used to produce cost estimates far more detailed than previously possible simply by virtue of being able to take into consideration more variables.

Section IV—Application to a particular problem

We will now discuss the application of the computer relative to a particular problem. The problem we will select for initial discussion is the calculation of influence lines on a five span bridge structure. The structure under question will have variable moments of inertia and each of the spans can be of different length. An experienced designer, who is doing this type of work all the time, will probably be able to make a calculation of this type in a few days. However, in the average design office a designer of this calibre is not usually free to devote his entire time, for even one day uninterruptedly, to one problem of this type. It has been found after careful survey of conditions in several offices that a problem of this nature will usually involve expenditure of at least $100 of direct payroll cost. This, with a normal overhead, works out to an actual job cost of the order of $200. Not only this, the time of an employee is tied up usually for about a week if we include the original design and the checking involved. There is also considerable and understandable reluctance to recalculate for a different set of conditions should any variations be found desirable. This is not so much due to the cost element as it is due to the time element involved in the design of the structure.

Let us suppose, that it is decided to apply an electronic computer to this particular problem:

1) **Problem statement.** To determine the moments at the supports and at mid-span for a load travelling across the entire bridge structure, load positions to be considered at the centre of each tenth point of each span. In addition, influence lines will be required for the reactions at each of the supports.

2) **Methods of computation.** Many methods of calculation could be used. In general, these may be classified into three broad categories:

a) Classical three-moment equation
b) Slope deflection
c) Moment distribution

Fig. 7. Bendix G 15 D Computer.

The first factor that needs to be considered is that the solution of simultaneous equations is not a difficult or lengthy problem for an electronic computer. Within certain limits imposed by economics, electronic computers can solve large numbers of simultaneous equations. The smaller computers can handle equations of the order of 29 x 29 and the larger computers equations up to 250 x 250.

The second consideration is that since the initial cost of programming will be very large in comparison to the operation cost, it is desirable to keep it to a minimum, provided that the operation expense does not suffer accordingly. Therefore, we tend to avoid methods such as moment distribution which will require elaborate planning at the program stage. This is where the three moment equation or slope deflection may, in certain cases, have an advantage over moment distribution. It is simple to set up a problem in concise terms using these methods. It must be remembered that the engineer does not participate in the individual stage or the computation. The computer cannot make decisions for itself. Therefore, all the possible situations that may arise must be thoroughly preplanned. And it is quite feasible in moment distribution to have certain situations arise which, under normal circumstances with manual operations, would not lead to any difficulties, but which, however, could lead to trouble on computer work. The engineer can exercise his judgement in deciding on the number of cycles to carry distribution. On applying this method to the computer he must predetermine the various situations that may arise and tell the computer what to do under the circumstances.

The three-moment equation approach has the advantage that it can be very simply stated in terms of the various properties of each individual span and the load position. This makes it possible to plan repeated cycles of calculation which are known as *loops*.

We thus see that moment distribution, while an admirable method for manual use, is not necessarily the

Fig. 8. Royal McBee LGP 30.

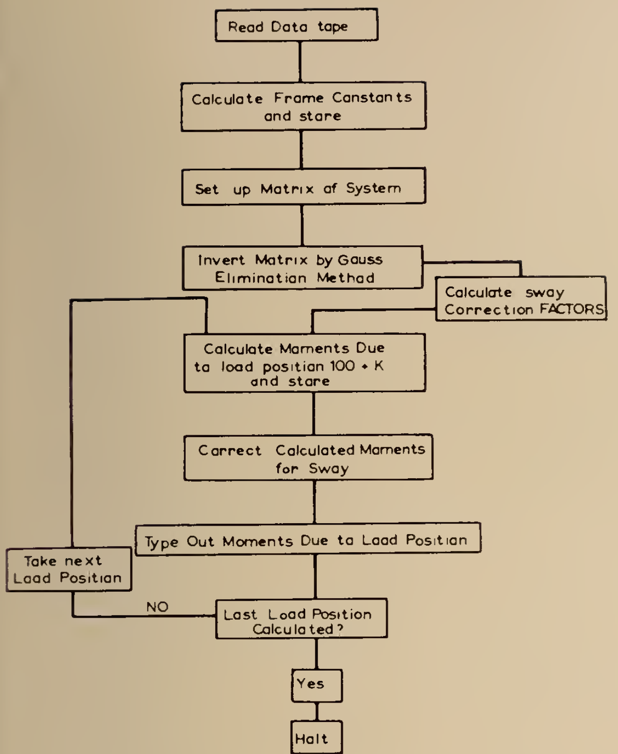


Fig. 9. Typical General Flow Sheet—Influence Line Program.

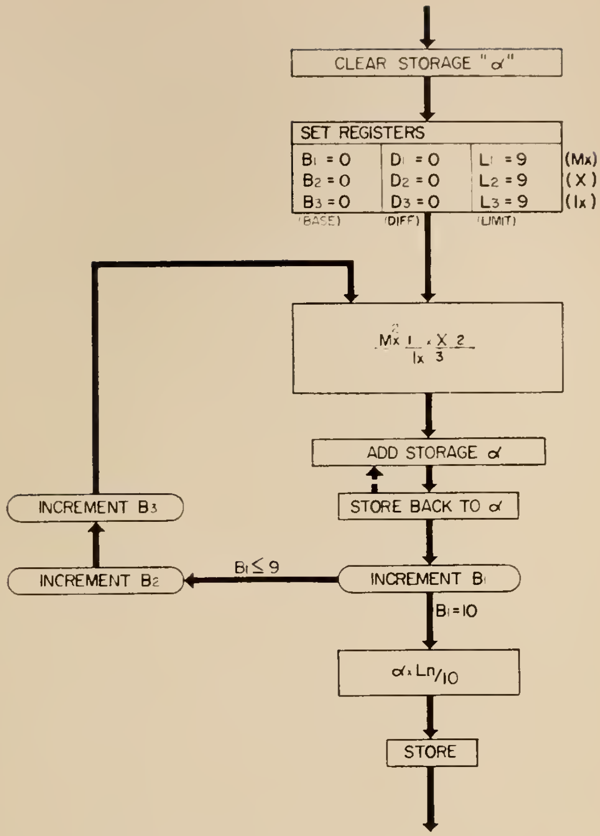


Fig. 10. Portion of detailed flow sheet.

solution for the computer. When putting a problem on the computer, it is often necessary to return to very first principles in order to achieve optimum results. We should caution the reader, however, that for large regular frames a form of moment distribution can be used to good effect.

3) **Selection of mode of operation for computer.** Having determined the method of calculation and having stated the problem, now it is necessary to select the computation medium and the means of operating that medium. For reasons previously discussed, insofar as the structural analysis is concerned for a problem of this nature, which is not going to be repeated a very large number of times, a medium-speed computer is usually the most economical. For the problem that we are discussing we have selected a Bendix G-15 computer which would be used as a means of demonstrating the method of solution.

There are several ways in which the computer can be operated. Each individual instruction can be given to the machine in what is known as *machine language*. When writing a program in this language it is necessary to detail to the very last step each individual operation. This means that to program such a simple operation as a multiplication, it is necessary to load the necessary portions of the rotating magnetic drum, tell the machine to carry out a certain number of operations, make the necessary transfers right or transfers left to take care of the decimal point location, and to replace the results in the proper storage slots in the proper sequence. There are many advantages to this type of programming which is known as *machine language programming*. Full advantage can be taken of the tremendous speed of the machine and this method is ideal for obtaining maximum efficiency out of the machine on short multi-reused problems. Fortunately, for the average application, it is neither necessary nor advisable to adopt this mode of operation. There are what is known as *interpretive routines*. These interpretive routines take very simple instructions, such as multiply, add, divide, subtract, etc. and convert them by means of the machine itself into a series of instructions to the various portions of the machine for the execution of the actual instruction. In this manner the programmer need not be concerned in detail with what is going on inside the equipment. It is true that a large amount of flexibility is lost and the actual operation of the program is considerably slowed down. This, however, must be balanced against the great simplification of programming and therefore the reduction of cost of the programming. There are different types of interpretive routines available to the programmer depending upon the circumstances. Some interpretive routines can eventually be converted to machine language by means of specially prepared computer programs. Such programs are called "compiler programs". It is well to remember, however, that very elegant procedures and highly efficient machine use almost inevitably depend on careful machine language planning.

Having selected a mode of computation, a flow-sheet is prepared. Fig. 9 shows a portion of the flow-sheet for the problem in question. This sheet is self-explanatory. This is a general flow-sheet, in other words a portion of the general attack on the problem. This outlines the method of solution to be used and can readily be followed by an engineer not at all familiar with the computer itself. This is a stage at which the program should be given the most critical appraisal not only by the programmer himself but also by all who are concerned with the eventual use of the program. It is at this stage that the validity of assumptions and methods must be studied. It is at this stage at which the scope, nature, and the extent of the program can be studied and therefore its usefulness assessed.

Fig. 10 shows a detailed flow-sheet. This flow-sheet takes the previous more general one and breaks it down into individual operations which will have to be carried out on the machine. As you will see, this is in considerable detail. On this chart a simple loop is shown. This particular computer has what is known as *index registers*. These are simple counting devices that enable us to determine the number of times a certain operation is repeated. Thus, in going through the computation shown on the board, we go through the additional multiplication loop once, the index register is increased by one, we go through the loop again, and the process being repeated until such time as the number of times for which the register has been preset is achieved. Once this number of operations has been completed, the computer proceeds to the next portion of the calculation.

Fig. 11 shows a portion of the final coded problem. This is the coded section for the detailed portion shown previously. We have standard code numbers for each individual operation. At the bottom of the picture you will see a description of some of the code numbers.

4) **Debugging.** After the coding is completed, the problem is now ready for the computer. First of all, this coding should be thoroughly checked. This particular problem involved 1600 instructions. It is almost impossible to avoid making some sort of error in coding. In fact, the recognition that the human element is subject to error is fundamental to computer applications. It is necessary to check out the program at every stage. This check-out is known as debugging. There are many classes of errors, such as:

a) Improper operation. Such an improper operation may be, for instance, division by zero. This is an obvious impossibility for the computer and therefore the computer rejects it.
b) Error in assignment of code numbers or address.
c) Typographical errors.

The above errors are usually detected by the simple reason that the computer refuses to operate, or produces results that are obviously in error.

Other errors are of a much more subtle nature. In a loop calculation of the type previously described, it is necessary to provide a means of getting out of the loop, otherwise the computer will not stop. Finally, it is necessary to check out a type problem to make sure that the right answer is being obtained.

Fig. 11. Typical Coding Sheet (Interpretive routine coding).

Notes	*Location*	*Oper. Code*	*Address*	*K*
$M_x = 580 - 589$, $I_x = 510 - 519$, $X = 420 - 429$ } storage locations	Stored α in 600			
Clear and add α	101	$4v$	600	0
Subtract α	102	59	600	0
$B_1 = 0$	103	$3x$	000	1
$B_2 = 0$	104	$3x$	000	2
$B_3 = 0$	105	$3x$	000	3
$D_1 = 1$	106	40	001	1
$D_2 = 1$	107	40	001	2
$D_3 = 1$	108	40	001	3
$L_1 = 9$	109	41	009	1
$L_2 = 9$	110	41	009	2
$L_3 = 9$	111	41	009	3
Clear and add M_x →	112	$4v$	580	1
Multiply by M_x	113	67	580	1
Multiply by x	114	67	420	2
Divide by I_x	115	$4z$	510	3
Add "α"	116	$5v$	600	0
Store back to "α"	117	$5x$	600	0
Increment 1	118	65	119	1
Increment 2	119	65	120	2
Increment 3	120	65	112	3
	121	.	.	
	122	.	.	
	.	.	.	
	.	.	.	
	.	.	.	

Debugging can often be by far the most costly part of the whole programming operation. It is one that requires careful attention on the part of the engineer and programmer, careful, logical thinking, and, above all, patience. However, there is one consolation, and that is, once a program is written, checked out and operating correctly on one problem, it will operate correctly on all other problems of the same type. As long as the human operator does not make a mistake, it is virtually impossible for the machine to do so. If the operator does make a mistake, a properly prepared program will detect it.

5) **Operation.** The operation of a prepared program is extremely simple. One needs only load the program tape into the machine, then load the data for an individual problem, and set the machine into operation and the desired results will be forthcoming, after the elapse of a certain length of time. The actual operation of the machine for a given problem is the simplest part of the whole operation. And obviously, where a problem is to be repeated many times the cost of programming and development costs associated with it are soon recovered.

Fig. 12 shows the portion of the output from a program for the calculation of a multiple span bridge with variable moment of inertia. The output in this particular case is in what is known as *floating decimal form*. This is a means that provides a neat compact arrangement and provides for the correct location of the decimal point. Fig. 13 shows a typical array of figures in floating point decimal form. This output mode is not essential and results can be obtained usually at a slight increase in program cost in fixed point form.

6) **Cost comparison.** It has been found that for the above problem the program development costs were about $3,500.00. It is anticipated that this and the related programs for the four and three-span bridge structures will be reused as much as 200 times over the next two years. This means that the amortized cost per use will be on the order of $17.50. On top of this, the machine operation cost for each time works out to approx. $48.00. This means that a five-span bridge of this type can be analysed on a computer of this type for a cost of approx. $65.00 total.

7) **Possible savings on higher speed equipment.** If higher speed equipment such as IBM 704 or Univac II were to be used, the operation cost would drop sharply. Once a program has

been formulated, i.e. written in terms suitable for lower speed computers, it is often quite feasible to make a conversion to the highest speed equipment. But since the rates per hour of the larger machines can be anywhere up to 20 times that on a slower machine, it is easy to see that the debugging costs could very easily climb. Also input-output time must be considered. The question of economics at this point is whether the repeated use of the program would justify the increased cost of the further speed possible on the higher speed equipment.

In general, it can be stated that the more repetitive the problem and the longer or more tedious it is, the more one should consider the use of very high-speed equipment. For problems that will not be repeated too often and for problems of a fairly complex nature it is often desirable to use a medium-speed computer so that the programming costs do not become excessive. It is very true that on high-speed equipment some extremely high-powered programming methods are available. It is still true, however, that an undetected logical error in the flow-charting will very rapidly consume a lot of time on high-speed computing equipment. A minute of silence costs far more at $750 per hour than at $40.

Load Position		Support Moments M_B	M_C	M_D
	Span 1	−51.18294	50.63170	−50.21050
		−51.53547	51.18490	−50.61613
		−51.85064	51.29373	−50.97877
		−52.11058	51.38186	−51.12724
		−52.12793	51.44175	−51.14720
		−52.13493	51.46592	−51.15525
		−52.12947	51.44707	−51.14897
		−52.11013	51.38029	−51.12672
		−51.76295	51.26345	−50.87787
		−51.28845	50.99604	−50.33190
	Span 2	−51.41540	−51.13281	50.44254
		−52.10648	−51.45213	51.15066
		−52.14837	−51.81134	51.27036
		−52.16705	−52.11705	51.39004
		−52.16421	−52.14735	51.49099
		−52.14472	−52.16598	51.55308
		−52.11443	−52.16740	51.55782
		−51.79285	−52.14743	51.49128
		−51.44438	−52.10452	51.34827
		−51.13329	−51.40000	51.13329
	Span 3	51.13329	−51.40000	−51.13329
		51.34827	−52.10452	−51.44438
		51.49128	−52.14743	−51.79285
		51.55782	−52.16740	−52.11443
		51.55308	−52.16598	−52.14472
		51.49099	−52.14735	−52.16421
		51.39004	−52.11705	−52.16705
		51.27035	−51.81133	−52.14837
		51.15066	−51.45213	−52.10648
		50.44254	−51.13281	−51.41540
	Span 4	−50.33190	50.99605	−51.28845
		−50.87787	51.26345	−51.76295
		−51.12672	51.38029	−52.11013
		−51.14897	51.44707	−52.12947
		−51.15525	51.46592	−52.13493
		−51.14720	51.44175	−52.12793
		−51.12724	51.38186	−52.11058
		−50.97877	51.29373	−51.85064
		−50.61613	51.18490	−51.53547
		−50.21050	50.63170	−51.18294

Fig. 12. Typical output for influence line problem.

Section V—New Theory

As discussed above, the methods of computation used on a computer must be selected so that they can make maximum use of the possibilities inherent in the computer. For instance, moment distribution was designed for manual operation, particularly manual operation with the slide-rule.

The computer has a different base of operation. In all fields of engineering, for instance, we have seen a shift in the methods of calculations used as a result of the introduction of electric desk calculators. Similarly, with the advent of the electronic computer we are going to see a shift and a development of methods particularly suitable for use on electronic computers. An example of such a shift is in the methods of computation of rigid frames. There is not time in this particular paper to dwell at any length upon this particular phase of the problem; a short example will suffice. The author has developed a method which combines certain of the advantages of moment distribution with certain of the advantages of the three-moment equation system as applied to electronic computer solution.

The basic theory rests on the principle that prior to loading all joints are considered to be frozen. After loading fixed moments are produced at the ends of each span. All the joints are then released simultaneously and obviously a correction is then applied to the fixed end moment previously obtained. An important principle at this point is that it is only this correction moment which causes rotation of the joints. Therefore the correction moment can be solved for using the three-moment equation. This means that it becomes possible in a multiple rigid frame to provide an absolutely general solution for the frame irrespective of the loading. This is done by applying successively to each individual joint a unit unbalance. Once this is obtained, we can prepare a table or store in suitable computer address locations the effects at every joint of a load which would produce a fixed end moment of x_n at any point in the frame.

This method produces a rather interesting type of simultaneous equation, namely one that consists of either four or three elements along a diagonal form in the matrix of the equations. Since we know that all equations for this type of problem will be in the same general form, it is possible to evolve a special solution of the simultaneous equations which is a good deal more efficient than an universal matrix inversion formula or the usual Gauss elimination for the solution of the equations.

Sidesway in the frame is taken care of in the same manner as in moment distribution. It is unfortunately not possible in the scope of this paper to

Fig. 13. Use of floating point notation to determine decimal position.

Numbers in floating point decimal		*Numbers in fixed point decimal*
47.12345	=	0.00012345
48.12345	=	0.0012345
49.12345	=	0.012345
50.12345	=	0.12345
51.12345	=	1.2345
52.12345	=	12.345
53.12345	=	123.45
54.12345	=	1234.5

discuss this approach in detail. It is mentioned here merely to point out that with the electronic computer a revision in our approach to problems is going to become necessary in order to take maximum advantage of the computer. It will be essential to re-examine our approach to engineering problems in the light of the facilities which are offered us by the electronic computer.

Section VI—Economics of computer applications

In the problems and applications mentioned above the electronic computer has demonstrated that it can achieve substantial savings in design costs for earthwork calculations, structural calculations, hydraulic calculations, traffic control problems, and a multitude of other cases. Moreover, it can be shown that there is a far more important side to the problem than this. Quite irrespective of the design costs, overall economies can be achieved by the means of much more thorough analysis and study of a given problem than was heretofore possible. In estimates of cubic yard cost for a particular earth moving job the method whereby that cost was derived will have to be studied. And in the course of studying it, attention will be focused upon the efficiency of the means for executing the work. Greater attention will therefore be brought to bear by the engineer on the means of executing his work and consequently greater efficiency will be the outcome. Initially, there is no doubt that the computer will be viewed with a certain amount of suspicion by those who feel that it may do the engineer out of work or that we all may become robots or machines of some kind. Actually, the author's own feeling is that the contrary will be true. He feels that the computer will remove the drudgery of calculations from the shoulders of the engineer and therefore will enable him to be free for much more creative thinking than he has been in the past.

Section VII—The future

As far as the future is concerned, it is difficult to predict what the acceptance of the computer will mean over the next five or ten years. It is safe to predict, however, that the automatic design of standardized or semi-standard structures will become common. A so-called semi-standardized structure is a structure designed for a particular application in which a structure of any particular type will be tailor-made to an individual job and yet will bear a general family relationship to other structures. As an example of this, the author has developed a program which will design a complete bridge and detail the structure, complete to the preparation of bar lists. The analysis of this structure involves some of the procedures mentioned before. In addition, it determines the optimum dimensions of the structure for a given loading condition so that the minimum cost is achieved. The cost being based, in this case, upon the price of concrete, the price of reinforcing steel laid, and the cost of form work. In addition to this, the dimensions and quantities for the given structure are calculated together with the elevations of the bridge deck to conform with the road profile. The computer program will prepare an accurate bar list for the individual structure.

Future developments, as mentioned before, are hard to predict. It is, however, quite feasible that the computer will undoubtedly become essential in the planning of all major projects involving a close scheduling of materials, careful inventory control, and careful manpower planning. Job cost controls are an obvious application of the computer in the contracting field. The extension of the idea of preparation of bar lists to other types of structures will mean that we will be freed from the drudgery of the preparation, checking and rechecking of these necessary but very tiresome accessories to construction. These developments must, of course, be individually measured in terms of the economic justification of the expense involved in setting up the necessary programs and routines to handle the work in question. However, these are economic limitations in which each case will have to be considered on its own merits. Insofar as the practical feasibility is concerned, the limitation is merely the limitation of the imagination on the part of the engineer himself.

C.B.C. TELEVISION NETWORK *(continued from page 67)*

is required for the second continuous replay, while as previously noted, the seventh machine is available as a spare in the event of electrical or mechanical breakdowns.

It will be observed that no provision has been made for duplicate recording and replay to guard against any failure resulting in loss of a recording. Such an insurance would double the requirement for operational machines. In spite of this, some duplication of recording is undertaken as and when machines are available.

Readers who are familiar with the Ampex VR1000 recorders will be aware that there is no positive method of monitoring during the recording process to ensure that the picture being seen is in fact being recorded on the tape. The recording process is based on the use of a frequency modulated RF carrier. During the recording process the RF signal at the output of the modulator is supplied to two paths, one being directly to the recording head and the other path being via a demodulator to a picture and waveform monitor. This system provides a check on the electronic circuitry of the recording system but unfortunately provides no check of the recording head.

During replay, control of the waveform and amplitude of the signal derived from the tape is provided. The signal is fed to the booth where after switching, it is fed via a Distribution Amplifier to the microwave network for onward transmission. No stabilizing amplifier is provided in the output of the booth for two reasons. In the first place, it was considered desirable to minimize the amount of equipment in the signal path following the recorder; secondly, absence of a stabilizing amplifier puts control of the waveform and amplitude in the hands of only one person, namely the tape machine operator. The intercom system permits the booth operator to call the attention of the tape machine operator to any incorrect condition of the output waveform.

Three programs are being handled simultaneously—one incoming and two outgoing. In order to maintain close liaison with the microwave network operator, all contact is made through the operator at the Delay Centre Master Control. To facilitate this, the Master Control operator is provided with picture, waveform and audio monitoring facilities for all programs simultaneously. This operator also maintains the fault log. See Fig. 7.

No editing of tape recordings is undertaken, chiefly because of the limited time available, but also because an additional tape recorder is required for such an operation. Editing is not normally required, however, since only completed programs already on the network are handled.

The basic number of operators required by the system is six, allocated on the basis of one operator to each pair of Ampex recorders (three in all), one in each of the two replay booths, and one at the Master Control position. This, of course, does not represent the total staff, since provision must be made for shift work, holiday reliefs and so on. In addition, some maintenance staff is required. Approximately twenty technicians, plus supervisory staff, are employed at the Delay Centre.

Emergency Operation

It will be recalled that two telecine chains are installed, each consisting of a vidicon camera into which are optically multiplexed two 16 mm projectors and a 2 in. x 2 in. slide projector. When the occasion arises to play film to the network the Ampex machine operator for the appropriate time zone replay performs the functions of projectionist. The booth operator, having the vidicon camera control unit adjacent to the operating position (see Fig. 6) carries out the function of camera control operator.

Results

Speaking generally—and bearing in mind the limited time which the equipment has been in use as of the date of writing—the results obtained have fully justified the decision made in 1956 to go ahead using video tape recorders as the means of delaying TV network programs. One is inclined to ponder upon the possible course of events had video tape recorders not made their appearance and had this project proceeded on the basis of a kinerecording system.

Acknowledgements

Thanks for permission to publish this paper are due to Mr. W. G. Richardson, Director of Engineering, and Mr. J. E. Hayes, Chief Engineer, both of the Canadian Broadcasting Corporation.

Thanks are also due to Mr. J. Carlisle, Plant Engineer, of the CBC, under whose general supervision this project was executed, and to Mr. P. Corio and Mr. P. Mundie for their invaluable assistance.

NIAGARA WATER SUPPLY TUNNELS *(continued from page 74)*

average *n* of 0.0114. It is considered that this comparison indicates satisfactory agreement between the formula values and the test results.

Computing the individual bend loss coefficients for each test on tunnel No. 1 indicated an undue variation in the value of *K*. However, by averaging the individual bend loss coefficients for all the tests more consistent results were obtained. These average values of *K*, and the values determined for tunnel No. 2, are shown on Fig. 8 where the bend loss coefficients are plotted against the deflection angles of the bend. Shown also is a mean bend loss coefficient curve which was derived from the average overall bend loss between piezometers 2 and 14 for all tests. This method was used to minimize the possible errors in measuring the relatively small losses at each bend. For comparison purposes, the bend loss coefficient curve obtained from the tests on the 6 in. pipe for an R D value of 5 is included in Fig. 8.

Discussion of Results

From Table IV it may be noted that the roughness coefficients obtained for tunnel No. 1 are quite consistent. Although the discharge used for tunnel No. 2 can be considered an estimate only, it would appear that the roughness coefficient for that tunnel is of the same order as for tunnel No. 1. It is believed that the No. 1 tunnel roughness coefficients are reliable, as the straight portions used in their determination were of considerable length and consequently the friction loss was large in relation to any probable error in piezometer level measurement. The discharge measurements also were considered to be satisfactory, their consistency being indicated in Fig. 6. Inspecting Fig. 7 it may be observed that the values of the roughness coefficients obtained are quite low and not much above those that would be expected from a theoretically smooth pipe. The relative roughness is also very low and it is considered that the surface smoothness achieved is most satisfactory.

The results of the bend loss tests were somewhat disappointing. From the tests on the 6 in. pipe, it was found that extreme accuracy and precision were required to obtain consistent values. This is basically due to the fact that the bend loss is a relatively small quantity obtained as a difference between two relatively large quantities, i.e., the total loss between piezometers and the loss due to friction. Any small error in either of the larger quantities has a large percentage effect on the resulting bend loss and on the bend loss coefficient. It would appear that the precision of the measurements was not sufficient to produce consistent bend loss values. It is possible that a piezometer ring, rather than a single piezometer, might have produced more satisfactory results. However, the results do indicate the order of the bend loss coefficients, and it is believed that the mean curve is a reasonable estimate of the actual losses due to the bends. Comparing these results with those obtained from the 6 in. pipe tests, it appears that the tunnel bend losses are approximately 60% of the 6 in. pipe values.

Conclusions

In terms of diameter and length, the Niagara tunnels are among the largest water supply tunnels in the world. A considerable effort was made to provide minimum loss bends and a smooth internal surface in view of the large economic value of maximum discharge capacity. It is considered that the results of the tests indicate a very satisfactory performance from this standpoint, the overall discharge capacity being almost identical to that assumed in the design. As little performance data is available for tunnels of this size, it is hoped that the results reported herein will be of interest and will add to the knowledge on this subject.

Acknowledgments

In the carrying out of the tests and the analysis of the results, the writers wish to acknowledge the very able assistance of Ontario Hydro's hydraulic testing staff. Particular mention should be made of Mr. G. L. Ball, who supervised the testing work, Mr. E. K. Beam who carried out the current meter measurements, and Mr. J. M. Spratt who carried out many of the computations.

RIVER ENGINEERING AS A COLLEGE COURSE FOR CIVIL ENGINEERS

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The author believes that the absence from civil engineering curricula of any effective instruction in river behaviour produces as serious national consequences as would the absence of soil mechanics. Within the limited space available he outlines reasons for this belief, and the possibilities of removing the deficiency.

The fundamental principle of river self-adjustment

STATED exceedingly briefly the fundamental feature of rivers that move non-cohesive material along their beds and have sides that are erodible is that they tend to adjust themselves to average breadths, depths, and slopes that depend on (a) the sequence of discharges imposed on them (b) the sediment load acquired by them from catchment erosion and erosion of their own boundaries and (c) the resistance of their cohesive banks to erosion. Geologists and specialist engineers, especially those who have had to deal with irrigation canals carrying sediment, have been generally acquainted with this principle for at least half a century and the specialist engineers have known satisfactory fundamental quantitative laws for some 30 years. Of course there are some rivers with entirely rigid inerodible boundaries and they do not self-adjust.

Typical engineering errors consequent on ignorance of the principle of self-adjustment

It would obviously be unfair to use specific instances to illustrate the misfortunes that have befallen engineering projects conceived in ignorance of the principle of self-adjustment. Accordingly the author has invented some hypothetical cases based on true life to demonstrate how ignorance of very simple phenomena, nearly all well known to geologists and specialists, can lead to major errors and even catastrophes in large civil engineering projects; resemblance between these cases and any real project is purely coincidental.

Case A

Province 'B', downstream, persuaded Province 'A', upstream, to agree to its building a dam on a river that flows from 'A' to 'B'. The dam ponded water right up to the boundary where A had a small town, upstream of which was a fertile alluvial plain. 'A' believed that the lake would be an amenity for the town and that the river upstream of the lake would continue to run as usual. Actually, within twenty years the town had to be abandoned because it became waterlogged and subject to enhanced high flood levels, and the enhanced waterlevels could be felt 20 miles upstream by farmers who suffered flooding, waterlogging, and deposition of river detritus on their good land. Apparently 'A' 's engineers who recommended acceptance of the proposal did not know the sediment load of the river, or that a delta would form, or that a river cannot run horizontally through a delta or anywhere else, or that artificially flattening the slope of a self-adjusting river causes deposition of load and a return to the original slope, or that the ultimate fate of the project (if left to itself) would be a reservoir full of sediment and a river running parallel to the old one at a height equal to the height of the dam above its old bed.

Case B

Country 'B', downstream, persuaded country 'A', upstream, which had rivers 'X', 'Y', 'Z' in common to divert river 'X' into river 'Y' for the benefit of irrigation in 'B' and, in return, country 'A' could have all the water rights of river 'Z'. The scheme was worked out entirely in terms of acres of irrigation and kilowatts of power without any consideration of what might happen to the rivers. When 'X' was diverted into 'Y' the latter started to erode its banks and to drop its levels. Within 20 years the breadth of the belt in which the river meandered had increased 50% over some 40 miles of river length, with consequent loss of agricultural land, the river had degraded up to 10 ft. in places, the products of enhaneed erosion had filled a reservoir in a canal system, an irrigation barrage had to be built to meet the rights of riverain dwellers who had been left high and dry by the receding river, and major repairs had to be made to a dam spillway that had suffered severe undercutting because of the same degradation. In this case 'A' 's engineers who recommended acceptance of the proposal did not know that, relatively, a big river adjusts itself to have a big meander belt and a flat slope.

Case C

A new highway crossed many meandering rivers. The bridge designers had river crossings surveyed and fixed the foundations of the piers at a certain number of feet below the river bed levels discovered at each pier site on the day of survey. Ten years later many of the high bed levels at piers had become low, and vice versa, many bridge piers and abutments had been propped up by masses of stone revetment and a few had been washed out by floods because stone had not been dumped in time. Many of the approach banks had had to receive expensive stone protection because the rivers had moved over to hit the roads some distance from the bridges and run along them; in one case a flood had gone right over a road and started a new river a mile away from a bridge. Here the engineers did not know that the *nature* of meandering rivers is to change course cyclically.

Case D

Without making measurements of sediment load at all stages of flow a high dam was built to store water for irrigation. After 10 years it was found that the reservoir had lost 15% capacity because of sediment deposition and was therefore no longer a guard against the once-in-20-years drought. All the settlers had occupied the irrigated area under the impression their reservoir would last forever, there was no other site for a large dam, and removal of the sediment mechanically was found to be quite uneconomic. Here the engineers had no knowledge of the rate at which deltas can form from heavily laden rivers, or perhaps imagined that deltas might form in the dead storage instead of at the entry of river into lake.

Case E

Engineers put the large spillway discharge of a reservoir down an old steep creek that had never carried more than a trickle. The original drop over the spillway was 15 ft. After 50 years the drop was 70 ft. and the spillway had been replaced by a chain of drops, each one having been made in the hope that there would be no more retrogression of levels. Here the engineers did not know how to relate discharge to the slope that nature required for it in a given soil; probably they did not even know there was a requirement.

Case F

In a system of unlined irrigation canals (controlled rivers actually) the engineers designed all the big channels to steep slopes so that cut and fill would balance, and all the small distributing ones to flat slopes so as to gain command of the fields. After 10 years they had had to protect all the bridge piers on the big channels, which had insisted on cutting down to flatter slopes, and had to face the perpetual cost and nuisance of annual sediment clearance of all the small channels which insisted on depositing their sediment load in an effort to obtain enough slope to carry it along. The engineers did not know about self-adjustment, and therefore did not know how to design the channels to carry their load to the fields and avoid erosion or deposition.

i.	Damage to agricultural land resources	$50 million
ii.	Damage from sedimentation in reservoirs	$50 million
iii.	Maintenance or impairment of capital value of drainage enterprises	$17 million
iv.	Maintenance of irrigation projects	$10 million
v.	Maintenance of harbours and navigable channels	$12 million
vi.	Water purification resulting from turbidity	$ 5 million
vii.	Sedimentation damages partly or wholly included in flood damage estimates	$20 million
viii.	Other damages (highways, railways, pipelines etc.)	$11 million

Cost of sedimentation in the U.S.A.

Naturally there is no good record of the costs, in different provinces or countries, of errors such as just described. An interesting assessment of the annual cost of sedimentation in the U.S.A. is contained in the welcoming address to a Federal Inter-Agency Sedimentation Conference of January 1948 (proceedings edited and prepared for publication by the U.S. Bureau of Reclamation). The author's personal guess is that most of the sedimentation could have been foreseen, and that this would have meant important differences in schemes actually executed. The assessment did not pretend to be anything more than an attempt to estimate the order of magnitude of annual cost with the object of demonstrating the importance of sedimentation, so the reader should not use the condensed breakdown (above) of annual costs in any other sense without reading the whole of the address:

An interesting statement re item (ii) is relevant to case (D) of the preceding section. It reads:

"The estimate is based essentially on the annual cost of fully maintaining the services now provided by these reservoirs through construction of additional storage or equivalent facilities as needed, plus the net losses if replacement is not possible. Additional storage must be provided in many drainage areas when 15-40% of the capacities of existing reservoirs are depleted. Often the supplementary storage will cost 2-10 times as much as the initial storage per acre-ft.".

Another interesting statement re item (i) is relevant to case (A). It reads:

". . . it should be borne in mind that sedimentation damage to agricultural land is cumulative, whereas floodwater damage is recurrent. For example: On a given piece of valley land which is overflowed on an average once in 5 years, sufficiently to produce a total crop loss, the loss is one-fifth of the potential net return. Take the same piece of land, however, and allow channel aggradation to raise the water table under the land so that crops cannot be grown at all, and the loss of return every year is 5 times as great".

Finally:

"Because the effects of many forms of sedimentation are slowly accumulating, however . . . because sedimentation is not generally spectacular like a flood, which is here today and gone tomorrow, leaving catastrophe in its wake . . . the true significance of the sediment problem has not been generally appreciated, even in the engineering profession, much less among laymen".

Importance of river knowledge in North America

The engineer's tremendous scope for construction in contemporary North America permits him to commit far greater errors than have occurred elsewhere. For example, the irirgation barrage system on the Indus and its tributaries that started late last century and has continued progressively to date has shown (Ref. 2) that every barrage results in the river upstream rising slowly but surely to the ultimate condition of parallelism with itself at a higher level fixed by the mean increased elevation at the barrage. (Changes of discharge and sediment distribution alter this simplified statement somewhat, but do not affect its general applicability to the present article.) The raising by the barrages, which were not intended for storage, was only a few feet in each case, there were no cities in the flood plains, the economy was somewhat primitive, and India and Pakistan now understand the phenomenon thoroughly and make future plans to allow for it. In North America engineers have thought nothing of damming rivers comparable in size and sediment load to heights of several hundred feet, there are cities or towns in some of the flood plains, the economy is far from primitive and, so far as the author can discover, engineers generally are unaware that there can be a sediment problem at all—some countries do not even conduct routine sediment surveys to find where there is a problem and the implications of some surveys do not seem to have been appreciated. (Of course, the trouble from a 100 ft. high barrage is not ten times that from a 10 ft. high one since a valley cannot rise faster, by deposition, than the rate corresponding to the total amount of sediment available for deposition). The interested reader will find, in Refs. 3 and 4, further examples that unfortunately do not separate the effects of wrong engineering from wrong soil conservation policies of the remoter past.

Engineering ethics in water disputes

Engineering and political ethics in water disputes is far too touchy a subject for generalization, but it is vital to a province's or country's interests, so the author will risk some personal observations. He has seen major water disputes either as a species of cold war or a tough game in which certain fouls are disbarred but the general idea is to beat the other side; he has also seen lifelong friendships between engineers fade away when they have found themselves on opposite sides in a water dispute. Under no circumstances would it be considered ethical for a member of one party to let moral scruples about outwitting the other cause him to divulge information that would interfere with the outwitting process. For example, in Case 'A' an engineer of Province 'B' who knew exactly what his province's proposals would do to damage Province 'A' if they were accepted could not be expected to inform Province 'A' about it although, so the author believes, he would be morally compelled to inform his own negotiators. And, in view of the possibly tremendous effects from wrong decisions, this brings us to the need for a country or province to have engineers to advise its negotiators (as *The Engineering Journal* has mentioned previously), and to be quite sure that these engineers are expert in river hydraulics (which is not taught in colleges).

Removal of ignorance of river behaviour

In the author's opinion ignorance of river behaviour is not universal; the trouble is that it is the prerogative of the civil engineers who build and plan water projects. If these civil engineers could cooperate with suitable geologists or specialist engineers, major errors would probably disappear. However, despite sincere efforts such as demonstrated by the Inter-Agency Sedimentation Conference, there are large practical difficulties. One is to find who really are the few suitable geologists and specialists. Another is to obtain effective cooperation between people whose experiences and outlooks are poles apart. Another, in our world of large insulated departments of central governments (most major water projects have to be central government ones if for no other reason than the refusal of rivers to recognize provincial boundaries) is to translate agreements amongst a few experts at a technical level up to a policy making level where similar agreement is possible; quite different departments of a government may divide amongst themselves aspects of river work that a scientist would say are vitally interlinked; e.g. soil conservation, dam building, navigation, diversions for irrigation and power, hydrologic studies, geomorphic studies, irrigation canal construction and running. On the whole the author, while heartily supporting cooperation between agencies, is of the opinion that the only effective solution is to offer civil engineering students the opportunity to study appropriately designed courses in river engineering, just as they now study soil mechanics. Then the civil engineers who plan and construct will know the principles affecting the rivers with which they interfere, and will be able to assess the magnitude of the consequences of these interferences.

Need for text books

River science might be classed as *geologic* because its phenomena cannot be studied adequately without world-wide coverage over periods of time comparable with a man's lifetime. Therefore, expertness cannot be acquired from personal experiences alone; reading the experiences of others is essential. But the subject is broad enough to receive contributions from workers of quite different outlooks, training, and abilities and, like all new sciences, abounds with apparent (often unreal) controversies; hence uncoordinated literature can be exceedingly difficult for a reader unacquainted with several branches of science and lacking critical ability. Therefore a coordinated text is needed to set out basic facts, develop equations representing observed quantitative correlations, explain them dynamically, apply them to practical problems, and give references to outstandingly useful or important literature. The author recently published a condensed but comprehensive text (Ref. 1) as a sequel to a previously privately published one, in the belief that a first book acts rather like a dam breach causing a flow of knowledge out of all proportion to its size.

Special Outlook needed by the river engineer

According to the writer's engineering and teaching experiences the school and college training of the engineer, engineering physicist or mathematical physicist usually leads to the subconscious beliefs that:

i. All physical phenomena meriting attention develop in a time comparable with that required for one physics or engineering laboratory exercise.

ii. Sufficiently complex mathematics removes the errors arising from the idealising assumptions of rigid body dynamics and rigid boundary hydrodynamics and is, in fact, a perfect substitute for physical knowledge.

It is exceedingly difficult to convince a person with this outlook of a host of facts that would be regarded as commonplace by a geologist or an agriculturist. For example, he would not believe that (a) a building placed on top of a wet clay cliff in 1958 might finish at the bottom during the next wet cycle of, say, 1998 because the layout associated with the building increased the water entering the subsoil, (b) the least time needed for observations of the relation between bed and side seepage of canals in the field, and the causes of seepage, is one year; and lack of intelligible results within three months is no reason for abandoning observations, (c) a tube-well irrigation scheme may deplete the water table so much in ten years that lift will be trebled and the wells will be drawing highly saline water (d) sediment-clearance of a channel will not stop sediment from entering from the catchment and redepositing. And, of course, he will repeat the errors of cases A-F in-

(*continued on page 95*)

MAGNETIC AMPLIFIER CONTROL FOR REVERSING HOT MILL AUXILIARIES

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This paper discusses in general terms the various performance requirements for the drive and control of auxiliary equipment associated with a reversing hot mill, and shows how magnetic amplifier regulators may be used to advantage to produce systems with the required high standard of performance.

Operation of the Reversing Hot Mill

When rolling either ingots into slabs or slab into plate the hot steel is passed back and forth between the work rolls of the mill. The thickness is successively reduced at each pass by an appropriate adjustment of the mill screws which control the separation between the work rolls. In order to avoid rolling material of non-uniform thickness it is imperative that the operation of adjusting the screws be carried out in the small time interval between passes when there is no steel between the work rolls. On the side of the mill at which steel is entering, the metal is carried on a series of regularly spaced horizontal table rolls which turn with a peripheral velocity approximately equal to the velocity at which the metal is entering the mill. A similar arrangement of table rolls on the exit side serves to convey the metal away from the mill.

The characteristics of the hot rolling process are such that the metal emerges from the mill at a velocity which very nearly equals the peripheral velocity of the work rolls. Since the steel cannot accumulate in the mill the volume of steel per unit time entering the mill must equal the volume per unit time leaving the mill. The velocity of the steel entering the mill will depend upon the rotational speed of the work rolls and the reduction in thickness being achieved. Thus if V_2 feet per minute is the exit velocity and d_2 inches is the exit thickness then if d_1 inches is the thickness of the steel entering the mill the entering velocity V_1 feet per minute will be defined by the following equation.

$$V_1 = V_2 \times \frac{d_2}{d_1} \qquad \ldots.(1)$$

On reversing the mill the functions of the tables on the exit and delivery sides are interchanged and it is evident that the table speed will have to be re-adjusted to conform to the requirements of equation 1 if there is to be no slippage between the table rolls and the metal. A convenient arrangement for the control of the table drives matches the table roll speed to that of the main drive and introduces an appropriate draught compensation signal to reduce the speed of the group of tables which are entering the steel into the mill.

It will readily be appreciated that once the metal has emerged from the mill at the completion of a pass the function of returning the metal to the mill is completely dependent upon the table rolls. Anytime during which steel is not between the work rolls of the mill represents a non-productive period in the cycle of operation. Successful design of hot mill drive and control equipment is to a large extent dependent upon the minimisation of the non-productive interval between passes. Delays in reversing the table drives are by no means the only cause of lost time between passes. At the end of each pass the mill screws have to be adjusted and the steel must not be allowed to enter between the work rolls until the screws have moved to produce the required separation for the next pass. Side guides are required to centre the metal on the tables before entering the mill and again, this centering operation must be achieved with a minimum of lost time. On blooming mills manipulators and fingers for turning the metal are required to operate between passes.

In a manually controlled mill reduction of lost time will, to a large extent, depend upon the skill of the operator, however, poorly designed auxiliary drives and control will place a very definite limit on productivity which cannot be exceeded by the operator. In automatically programmed mills the operation does not depend upon the human element and in these cases the efficient utilisation of the mill will be critically dependent upon the operational characteristics of the auxiliary drives.

A considerable number of auxiliary drives with their associated regulators and control, are necessary to ensure the satisfactory operation of the modern reversing hot mill. For example, regulators are required for mill tables, feed rolls, side guides, mill screws and edger screws. In a comparatively simple installation some fifteen or more regulators would be required for the proper control of the mill auxiliaries. Since failure of any one of these may render the mill inoperative, reliability and simplicity cannot be too strongly emphasized in the design of the equipment. Magnetic amplifiers operating from a separate 400 c/s supply have been successfully used for the regulation and control of these auxiliary drives. The size and arrangement of the drive motors used in this application require d-c. generators with a capacity of 200 kw. or less. With machines of this rating it becomes economically feasible to excite the generator fields directly from magnetic amplifiers. This arrangement eliminates the need for an interposing exciter and provides a very simple design which has associated with it all the advantages of static type equipment. This basically simple type of regulator has been successfully applied, with slight modification to all types of reversing mill auxiliaries, however, for the purposes of this paper the table roll drives have been selected as being a typical example of the application of magnetic amplifiers in this field, and the detailed discussion which follows has been restricted to this topic.

Limitations on Table Roll Acceleration

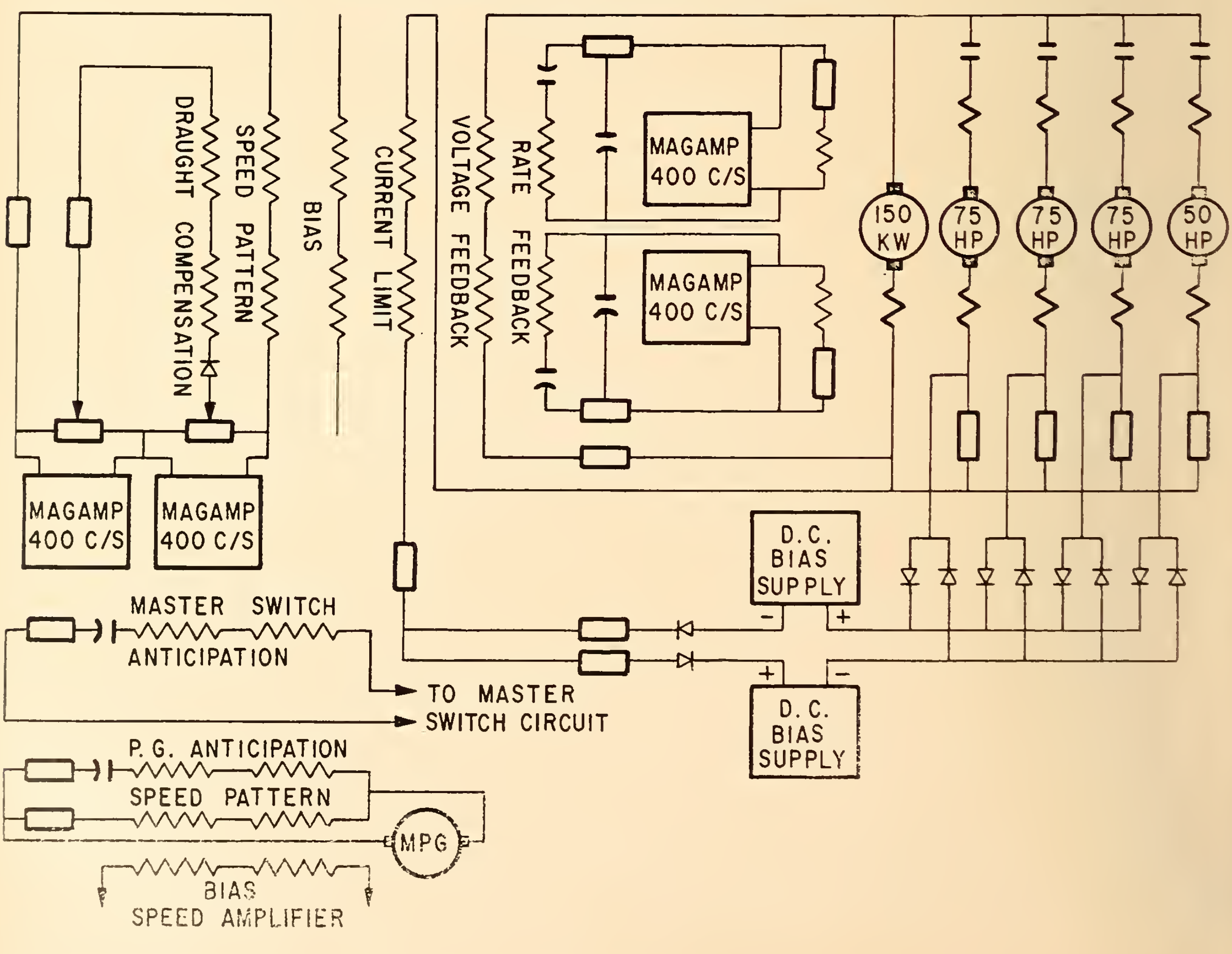
The table roll drives can only accelerate the metal at a rate which is uniquely dependent upon the coefficient of friction between the metal and the table rolls. The exact value of the coefficient of friction is difficult to determine, but taking a somewhat conservative estimate of 0.25 then the maximum acceleration possible without slippage is 480 ft. per minute per second. A hot mill reversing from base speed forward to base speed reverse in 1½ seconds may well be accelerating the metal at a rate of 450 ft. per minute per second and in such cases the question of slippage on the table rolls due to non-uniform acceleration may become important.

As well as being a factor limiting the maximum acceleration of the metal, slippage is also undesirable in so far that excessive slipping causes unnecessary wear on the table rolls.

The Table Roll Drive Regulator

Control of table roll speed is exercised by regulation of the table roll generator voltage. A voltage regulator gain of approximately 10 produces a system with adequate accuracy. At first sight it might appear that precise regulation of the table roll speed would be desirable, and certainly this is the necessary requirement if there is to be no slippage between the table rolls and the metal. However, it would be extremely difficult to achieve a precise speed match and even if this were possible the control equipment would be both complicated and expensive. The first difficulty arises in determining the precise speed of the metal entering and leaving the mill. There will always be some extrusion effect which will result in the metal leaving the

Fig. 1. Table roll voltage regulator and speed amplifier.



mill at a velocity slightly in excess of the peripheral speed of the work rolls. Unless an exact draught compensation adjustment is made every time the screwdown setting is changed, the entry speed of the table rolls will be in error even presuming that the exit speed is accurately known. Normal rolling practice is to set the draught compensation at some intermediate value which will provide a satisfactory comprise for all passes in a particular schedule. During the early passes the metal is almost continually accelerating or decelerating, very rarely running at a constant velocity for an appreciable period of time. In terms of regulator performance this would mean that the speed regulator would have to follow a rapidly varying input signal with no transient error. In general it may be said that precise speed regulation would present considerable difficulties in terms of regulator design and it is doubtful even if an accurate speed match were obtainable, if this would provide any significant advantage to the mill operator.

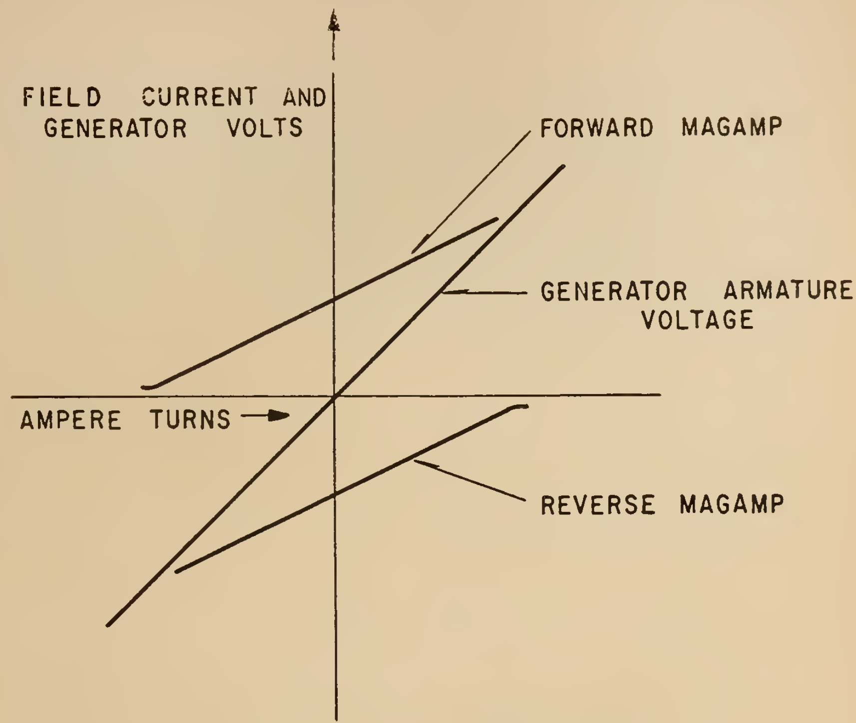


Fig. 2. Magnetic amplifier characteristics.

The voltage regulator with a gain of 10 could be expected to result in a system which will have a speed droop from no load to full load which is approximately equal to the speed droop of the table roll motors. Under steady-state conditions (i.e. constant speed) the motors will only be lightly loaded, the large torques being required only for accelerating and decelerating and, therefore, the drooping characteristic of the motors and their associated armature resistors is unlikely to seriously impair the accuracy of the speed match on the longer passes when the mill attains a constant rolling speed. The basic magnetic amplifier regulator is shown in schematic form in Fig. 1. The arrangement is a simple two delay regulator comprising the magnetic amplifier delay and the generator field delay. Two magnetic amplifiers are used to provide push-pull operation, thus enabling the polarity of the generator armature voltage to be reversed without using contactor switching. The characteristics of the two magnetic amplifiers are shown in Fig. 2, which illustrates how the combined reversible characteristic is obtained from the two individual unidirectional magnetic amplifiers. A typical arrangement is shown in block diagram form in Fig. 3. The overall open loop transfer function for the system is:

$$\frac{7}{(1 + .05S)(1 + 2S)}$$

The characteristic equation can be written down by inspection as:—

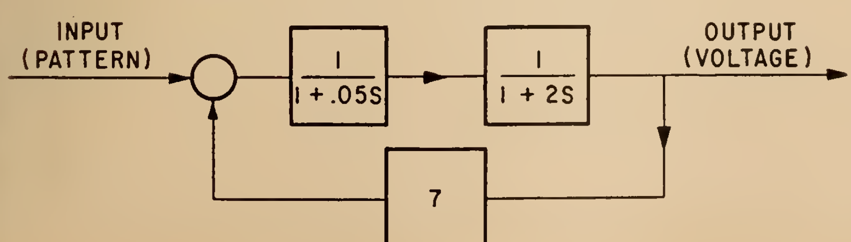
$$.1S^2 + 2.05S + 1 + 7 = 0$$

$$S^2 + 20.5S + 80 = 0$$

Hence the resonant frequency of the system will be $\sqrt{80}$ radians per second or 1.42 cycles per second. The damping factor will be 1.15 hence the system will be satisfactorily stable, being slightly overdamped in this case. The rise time will be approximately 0.25 seconds which is sufficiently fast in comparison with 1.5 seconds base speed reversal time of the mill with which the tables have to keep pace.

In arriving at this conclusion to confirm the adequacy of the speed of response it must be remembered that for large changes in speed the rise time will be reduced since the magnetic amplifiers will saturate thus placing a limit on the maximum voltage available for forcing the generator field. In practice there is always a tendency for the acceleration of the mill to reduce as it approaches its maximum speed and, therefore, the tables are not required to maintain a constant acceleration over their full speed range. In practice no difficulty was encountered on this account even when the maximum forcing allowable was somewhat under 50% of the full excitation voltage. In practice the table drives are required either to operate from a signal proportional to mill speed or from an independent master switch. In the case of the master switch step signals are applied to the voltage regulator. Under these conditions it is necessary to supply current limit protection to maintain the maximum armature currents within a safe value and prevent the motor overloads from

Fig. 3. Table roll voltage regulator—block diagram.



being tripped out when accelerating or decelerating. There is not the same definite requirement for current limit when operating from signals proportional to mill speed as the speed changes involved in this case are limited to the maximum acceleration of the main drive. However, the table motors are usually selected so that the maximum permissible armature current is used for acceleration and deceleration and on this account it is desirable to have current limit protection to prevent the possibility of overload tripping during speed changes. As more than one motor is connected to the generator it becomes necessary to use a selective type of current limit circuit so that no matter which motor happens to be operating at a limiting value of armature current it will feed a current limit signal to the regulator to change the generator voltage in such a way as to reduce the current flowing.

This selective type of current limit circuit is shown in Fig. 1. Current limit action will commence as soon as the voltage across any one armature resistor exceeds the potential of the bias supply. The individual rectifiers connected to each armature resistor prevent current circulating between the circuits and they permit only the rectifier connected to the resistor with the greatest potential drop to conduct. Current will then flow through the series blocking rectifier to produce the desired signal in the magnetic amplifier control winding. The purpose of the blocking rectifier is to prevent any current flow through the winding due to the bias supply alone. An additional set of rectifiers and a bias supply is provided to give current limit protection for either direction of current flow through the armature circuit.

If the drive were run at full speed and an increasing load torque gradually applied to the motor, the motor speed would reduce slightly by virtue of the speed droop in the motor until the armature current increased to a value where current limit action starts. As the load is increased the drive will slow down and armature current will increase until under stalled conditions the current will have increased to a value which is sufficient to produce a signal in the magnetic amplifier winding which almost completely counteracts the effect of the signal in the pattern winding. The higher the gain around the current limit control loop the less will be the increase in current between the value at which current limit starts and the value at which the drive stalls.

In practice it was found necessary to introduce a rate stabilizing loop around the magnetic amplifier in order to obtain a gain which was high enough to provide a sufficiently small difference between the stall current and the value at which current limit started.

The tables are matched to the speed of the mill by maintaining the table roll generator voltage proportional to the voltage generated by a tachometer driven by the mill stand drive motor. The simple idea of feeding a pattern signal from the pilot generator to the voltage regulator is inadequate for practical purposes, as tables controlled in this way will always tend to lag behind the mill speed during periods of acceleration and deceleration. In order to overcome this tendency of the tables to lag behind the mill it is necessary to feed an anticipatory signal to the table generator voltage regulator. This may take the form of a rate of change of pattern signal, or a transient pulse initiated from the main mill master speed control switch or a combination of both. The circuit incorporating this feature is shown in Fig. 1. In order to avoid the complication of using individual anticipation circuits on every table drive regulator a speed amplifier has been introduced to amplify the signal from the mill stand tachometer generator, and provide a common output which is fed to all regulators. The speed amplifier comprises two push-pull 400 c/s magnetic amplifiers which permit the incorporation of the two rate circuits on the input side, thus avoiding the necessity for duplicating these circuits on every individual regulator. A separate output is taken from the speed amplifier through a blocking rectifier, which allows a draught compensation signal to flow in the table drive regulators for only one polarity of speed amplifier output. The polarity of the speed amplifier is dependent upon the direction of rotation of the main mill drive and it is, therefore, possible to arrange for the draught compensation signal to effect only those tables which are entering metal into the mill. Hence it is necessary to use two blocking rectifiers connected with opposite polarity such that one rectifier serves the tables on the entry side and the other on the delivery side.

Conclusion

Auxiliary drive regulator circuits of the type discussed in this paper have been operating for a period of approximately two years on a reversing 2 HI hot mill at Hamilton, Ontario. The low maintenance record on this particular installation has done much to substantiate the claims made for the advantages of this basically simple magnetic amplifier arrangement and the satisfactory performance obtained has confirmed the validity of the theoretical considerations which formed the basis of the regulator design.

No. 7

of a Series

INSTRUMENTATION IN INDUSTRY

FOUNDRIES AND STEEL MAKING

THE SURVEY of instrument usage in Canadian foundries and steel making industries showed a strong basic reliance upon the skill and experience of operators using manual methods, but there was a strong undercurrent of interest in automatic instrumentation evident among those replying to the *Journal's* questionnaire. In those cases where advanced instrumentation control systems had been investigated and installed, it appeared that the techniques used— and the results obtained — were equal to, or in advance, of those used in other parts of the western world.

The most commonly used systems appeared in temperature control devices, continuous casting devices, pressure and air control devices and in general furnace control. While these areas of activity are often interrelated, the control of temperature by automatic regulation of the fuel-air mixture is so widespread that it appears to be considered a necessary economic measure by most of those replying, and therefore it commands a separate mention in any report on instrumentation usage in this country. Since heat is the ever-present factor in foundries and steel making plants, it is not surprising to find systems ranging from simple on-off regulators providing two or more preset "fuel-air" mixtures to fully integrated electronically controlled loops which continuously monitor the product of combustion — or the product of the furnace, and adjust the air-fuel mixture for most efficient operation at any given time. The most general control loop appears to be combination electrical-mechanical in nature, with the error signals being transmitted to an amplifier as an electrical signal, which in turn drives a control motor activating a valve in a pneumatic servo loop adjusting the air supply. The great reliance placed on hydraulic servos in the industry at the present time seems to rest firmly on the requirement for a robust and trouble free mechanism which is extremely reliable, and which is not apt to appear too mystifying to the average operator. While it is true that many electronic systems are now made to be extremely reliable, most users appeared not too happy with the requirement for additional links such as relays, syncros for remote control, etc. Since it is not practical to drive servo-motors larger than about ½ h.p. directly from power amplifiers, it is axiomatic that relays and other transfer methods must be used, and a lot of the respondents did not like the idea.

Instrumented continuous casting is being successfully carried out by at least one of the organizations reporting, and the results are considered to be excellent. The instrumentation used is not complex, and represents a practical compromise on the problems associated with isolating and controlling a set of very complicated operating variables such as molten and solid metal temperatures, molten metal levels, casting machine speed, cooling water temperature and flow rates.

Operations having to do with pressure and air flow are commonly associated with furnace control and efficient production of high quality products with reduction in waste. A great deal of interest was evident in the application of tuyere control to blast furnaces which is being used at a number of installations on this continent. By properly regulating the flow of air to the tuyeres surrounding the furnace, a more uniform product is produced, and the elimination of hot spots caused by clogged tuyeres and channelling results in longer furnace life.

The ideal situation sought in the industry calls for fully automatic operation of the furnace cycle, including automatic detection of hot spots by the use of thermocouples or other appropriate transducers, variable charging rates to automatically eliminate hot spots when they occur, control of physical properties of air and other gases used in the process by continuous monitor, analysis and regulation of the flow, and control of quality through continuous analysis of output gases and automatic adjustment of the various raw materials used to charge the furnace.

Common Problems in Automation

Some of the more serious difficulties encountered in realizing these goals have been problems associated with accurate analysis of furnace gases, the need for better temperature transducers and mounting racks, and the need for a wider range of rugged, reliable servo loop components which can stand the abuse of long life in a hot, dusty, gaseous environment.

Many respondents indicated that they were unable to obtain a range of standard control components in this country, with the result that a very large part of the instrumentation for automatic or semi-automatic control is imported, or merely assembled in Canada. Most of those who mentioned the quality of the control engineering services offered by Canadian firms, however, were well pleased with the quality of these services.

They did, however, mention the usual problem of not being able to interest many qualified designers and manufacturers in the limited volume of work available. In many cases, the dollar value of the job is so small that it cannot support development costs, and the only alternative is to turn to imported goods and services.

While not a direct subject of the *Journal's* survey, it is interesting to note in the trade magazines the increasing mention of automation activities in foundries and steel making in the Soviet Union. Apparently it has been appreciated that their only hope of attaining the high rates of production programmed under their various plans is to make an all out effort to advance automation technology and many of their recent installations require very little human attention.

Power and Steam

None of the respondents develop electrical power for their own plant, but 75% of them check consumption of purchased power with their own instruments. Steam plants are used for heating only, and most of the larger companies run a fairly small steam plant for this purpose.

Uses of Instrument

The most commonly used instruments were those designed to measure and regulate temperature in various parts of the production process. As might be expected, such temperature instruments cover a wide range, but the most general types are used for the measurement of molten metal, and are of the pyrometer or thermocouple type. A large number of recording instruments are used, especially in those cases where instrumentation has advanced to the stage where there has been a sizeable reduction in the labour force. The recorded parameters are generally used to provide information for manual correction of processes, or as an aid in laboratory analysis of operating conditions. There were a few reports of self regulating servomechanism loops, mainly to control such things as pouring rates of pouring ladles, air-fuel mixtures — especially on oil fired furnaces — and in raw material fabrication processes. One firm holds slab heat for a planetary rolling mill between closely controlled limits by use of instrumentation, and the same plant has a fairly elaborate system of warning and safety devices designed to minimize danger to the equipment and to operating personnel.

The most commonly quoted purpose for instrument installations was to achieve better quality. The next most important purpose was to provide a continuous record of operations, while less important purposes were to provide supervisory or warning signals, to reduce skill requirements in the labour force, and to regulate pressure or flow. Economy in fuel consumption was another important purpose of instrument installations.

Who Determines Instrument Requirements?

In all of the companies responding to the *Engineering Journal's* questionnaire, company employees are primarily responsible for determining the company's instrument requirements. However, approximately 25% of the companies also used the services of manufacturers of instruments, and in the case of one of the smaller ones, this was the only instrument engineering service used. One or two respondents indicated that they also rely on independent consultants for the determination of their company's requirements.

Purchasing

This industry was less unanimous than others canvassed in the specification and recommendation of instruments to be purchased by the engineering department. While engineering departments still have the greatest say in the brands and types required, there were a number of firms which place this responsibility with the production department. They felt that the persons who use the equipment should have most to say in its procurement—provided, of course, that engineering performance specifications are met.

This questionnaire result requires careful interpretation however, since 85% of the respondents represented small firms with total investment less than $5,000,000.00 The larger firms show the standard pattern whereby instruments are completely specified by the engineering department, and are purchased under their direct supervision by a purchasing department which exercises little control other than to obtain the instruments at the most advantageous price.

Servicing

A wide range of servicing schemes were used, with about equal favour shown to servicing by company employees and the purchase of a service contract from the supplier. One respondent contracts for all his service requirements from an independent serviceman, and in two other cases the service requirements are purchased as required without benefit of contractual arrangements.

Preventative Maintenance

All but one of the firms replying to the questionnaire indicated that they operate a preventative maintenance scheme for their instruments. This is the most unanimous result obtained on this question to date, and seems to indicate that the foundry and steel making industry regard preventative maintenance programs as good business procedure. One of the reasons for such thinking is evident in the repeated reference to the continuous nature of most of the processes, and in the high cost of failures when they occur. While not directly stated, there was a fair amount of reference to the fact that many of the operating personnel regard highly instrumented systems as something of a mystery. Therefore, they are reluctant to delve into even the most simple failures, and instruments which operate without service failures build up confidence and operator moral. These factors all add up to an almost unanimous decision that preventative maintenance programs are a desirable thing, and well worth the money they cost.

Spare Parts Policy

Most companies in this industrial group—90% of those responding — keep a stock of spare parts built up through operating experience. Only one of those replying utilized the recommended spare parts list issued by the manufacturer, and this was not used exclusively—it was combined with the practice of maintaining spare parts built up from "experience lists". Only one of the respondents—one of the larger firms in the country—kept a limited stock of complete replacement units.

There was very little general interest in instruments incorporating optional plug-in features—in fact only one firm indicated that they were particularly suited to their needs. However, it is significant that this firm is one of the most highly automated in the country, and their expenditures on instrumentation was considerably higher than any of the others reported. Plug-in features are especially appreciated in electronic servomechanism systems where power supplies, amplifiers, and adapters may be easily replaced with serviceable units when trouble occurs. This considerably improves the maintenance problem, especially where non-technical operators are concerned. The modification of performance characteristics by the use of various adapters is an important secondary advantage of plug-in units, and is especially helpful when there is a large amount of automatic equipment installed in a plant. To obtain optimum advantage, however, it is necessary to design along certain basic lines, or the advantages of interchangeability of amplifiers, power supplies, etc. will be lost.

What Type of Instruments are Supplied?

The *Journal's* questionnaire has observed a common denominator on this point — practically all users want standard lines of instruments which they can adapt directly to their use, preferably without modification. While this is a very understandable objective, especially when one observes the cost of designing to specification, it may not yield the best results in all cases, and there is probably a field of activity here for a low-overhead instrument service which can supply tailor-made systems at prices not too far above those of standard lines. The resulting improved performance must outweigh the advantage of simplified servicing implied in the preference for standard products.

Statistics on Instrument Costs

All but one of the respondents purchases instruments outright, and in that case 2% of instrument requirements are rented as required. Capital investment in instruments varied widely and ranged from $5,000.00 to over $500,000.00. The majority of those reporting were smaller firms, and only two were in the "over $500,000.00" category for capital investment in instrumentation.

Most respondents indicated their annual maintenance costs for instruments to be in the $3000.00-$5000.00 range. One firm spends approximately $75,000.00 per year on maintenance and there were two in the $30,000.00-$40,000.00 per year range.

The general trend in this industry appears to be to seek rapid recovery of money invested in new instrument installations, and in most of the cases reporting it was stated that recovery of capital cost must be accomplished.

RIVER ENGINEERING *(Continued from page 88)*

definitely, firmly convinced their consequences are inexplicable accidents that will not recur. If he does happen to feel he needs advice he is more likely to ask it from a mathematician than from a geologist. Yet his basic trouble is that he has never had to think about the relatively slow and complex processes of nature such as concern geologists, agriculturists, geneticists, bacteriologists and a host of other scientists whose work gives them the time-sense he lacks.

College instruction

Fitting instruction into a college program is an administrative problem differing among universities and countries. In countries whose schools provide a standard of English, mathematics and physics that does not need to be supplemented in the colleges, the introduction of a couple of new courses at undergraduate level probably poses no problem. The writer is of the opinion that, however river engineering is introduced, it should be accompanied by a separate course in geomorphology to ensure (if nothing else) that the engineer acquires a timse-sense appropriate to phenomena he will encounter in dealing with natural channels and with various important field problems of soil mechanics. Further, he prefers it to be taught according to the system of Ref. 1 which does not rely on assumptions to which rigid-boundary hydraulics is applied but, instead, depends on dynamically satisfactory equations derived by observing actual channel self-adjustment in the field; that is, he prefers the approach of classic physics, via observations of facts, their correlation, and then the explanation and use of equations expressing the correlations.

At the University of Alberta ten years ago the elements of river engineering were taught in the undergraduate irrigation engineering course that dealt with project design (and not application of water in the fields). Now river engineering, considered as basic and applied mobile boundary hydraulics, is a post-graduate course for students majoring in hydraulics, but is taken by a fair number of soil mechanics graduates. The non-mathematical type of hydraulics student takes geomorphology in addition, and the mathematical type is advised to take it if he intends to become a practising river engineer. Advanced mathematics is not needed for river engineering except, of course, to the extent that it can be used by all students of science to improve their ability to think precisely.

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Canadian Developments

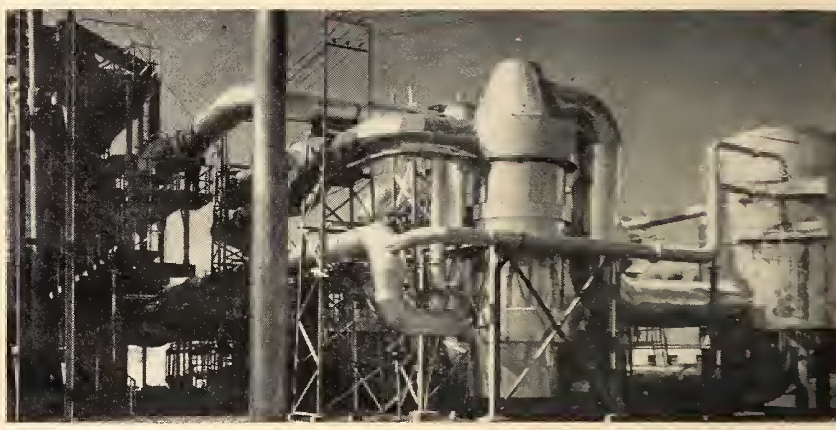
NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

Industrial Advances

C-I-L Developments

The new $2 million ammonia oxidation unit for the production of nitric acid at the explosives works of Canadian Industries Limited at Beloeil, Quebec, contains advanced features in its control mechanisms and in its means of utilizing heat and waste gases given off in the reaction. A turbine driven by waste gases provides part of the power for the air compressor. The new unit went on stream late in 1958, designed for C-I-L by Chemical Construction Company.

In the process, filtered air is compressed to about 100 lbs. per sq. in. in a two-stage compressor. The air is mixed with vapourized ammonia and the mixture is passed through a platinum gauze catalyst. The hot gases resulting — mainly nitric oxide at about 900 degrees C. — flow through a series of heat exchangers and are further cooled and partly condensed in a cooler condenser.



Converters containing a vanadium catalyst are part of C-I-L's sulphuric acid plant at the explosives works, Beloeil, Que.

Dominion Tar continuous tar distillation plant, Hamilton.

The gases are fed in at the bottom of the absorption tower, where they are met by a flow of air that oxidizes the nitric oxide to dioxide. Water is fed in at the top. The interior of the tower contains a number of trays through which the nitric dioxide passes to become absorbed by the water to form acid. The concentration of the acid increases as it descends from one level to the next until, at the bottom, it is drawn off at 60 per cent strength.

Waste gases, which are not absorbed, are heated and piped back to drive a turbine which provides a portion of the power required by the air compressor.

Concentrated nitric acid is produced by dehydrating the 60 per cent acid with concentrated sulphuric acid and vaporizing the nitric acid from the mixture. The nitric vapor is condensed to produce an acid of about 98 per cent strength.

At Beloeil, also, a new million dollar sulphuric acid plant went into production in 1958. Designed and constructed by Chemiebau Canada Limited, the outdoor-type plant manufactures acid from sulphur by means of the contact process.

Hamilton Tar Plant

The new plant of the Coal Tar Products Division of Dominion Tar and Chemical Company Limited, at Hamilton, is the first continuous tar distilling plant in Canada. The plant receives coal tar, a by-product of the coking operation in steel plants, and produces distillates and coal tar pitches.

In this new operation, crude tar containing one to three per cent water is heated in the convection section of an oil fired tube heater and again in a trimming heat exchanger to 200°C and fed to a twelve plate dehydrating column, where water and light ends in the benzene, toluene, xylene range are removed as overhead. The water is decanted to waste treatment and the light oil pumped to storage.

The dry tar from the bottom of the dehydrating column is pumped back through the radiant section of the tube heater and flashed into the bottom of a 27 plate fractionation tower. The overhead from this tower is in the solvent naphtha range and contains the tar acids and cumerone-indene resins. Two side draws are taken, one containing 70-75% naphthalene and the second, oils boiling in the creosote range. Heat is recovered from the creosote fraction by exchange with the feed tar.

The column operates at 50 mm of mercury with vacuum provided by a two stage steam ejector. The melting point of the pitch residue in the bottom of the column is controlled by the temperature of the feed tar and the creosote draw-off. The products are pumped to storage.

The first section of the plant went into operation in October, 1958, with formal opening in May 1959. Engineering and construction were by Canadian Badger Company Limited.

Asbestos-Cement Pipe Plant

Quebec's first plant for the manufacture of asbestos-cement pipe was officially opened in May, at Montreal East, Que.

Automatic control plays an important role in the manufacture of asbestos-cement pipe here. Selected types and grades of asbestos fibre are automatically weighed, blended and dispensed into a fiberizer designed for treating asbestos fibre. Simultaneously, portland cement and silica are weighed and blended. All three components through electronic controls merge into a common blender. The dry mixed ingredients then flow to the wet conveyor where water is introduced, thence into the stock in the form of a slurry of uniform consistency.

Slurry feed is closely controlled from the stock chest to the pipe machine vat where it is picked up by the cylinder and transferred to the felt in the form of lamina.

Heavy steel mandrels of the correct diameter are automatically fed into the machine to receive the build-up of laminations under pressure. Lamination thickness and pressures are closely controlled to provide an end product which is uniform in structure. A feature of this machine is calendaring of the wet pipe.

After an initial set in the pre-curing oven, the mandrel is extracted revealing a rigid asbestos-cement pipe. Additional curing is achieved in the final pass of the pipe through the oven to the take off point.

From the pipe making machine the pipe is laid in specially designed bogies and placed in one of three autoclaves where it is subjected to an atmosphere of live, high-pressure steam.

Two Ontario Developments

Plate and Structural Steel Limited, have acquired a new plant, as a step in a planned program of expansion. *DuPont of Canada Limited* have begun production of polyethylene film at its new extrusion plant at Whitby, Ont.

Dominion Foundries Expansion

Dominion Foundries and Steel Limited, Hamilton, Ontario, will install a third Oxyton plant with capacity of 150 tons of oxygen per day.

The company first started operation of the oxygen steel making process in 1954. It now has three 60-ton capacity furnaces, employed on a rotation basis. The current $15 to $20 million expansion program will increase ingot ton potential from 750,000 to one million tons annually by the fall of 1959. Hot rolling and cold rolling facilities are also being enlarged.

Union Carbide Polyethylene Expansion

The third major expansion of polyethylene production at Montreal East is announced by Carbide Chemicals Company, Division of Union Carbide Canada Limited. With the new facilities the plant will have an annual polyethylene capacity of over 65 million pounds. Construction has commenced and completion is scheduled for early 1960. The second expansion phase has just been completed.

Iron and Steel Smelter in B.C.

Consolidated Mining and Smelting Company of Canada Limited, announced in April that construction will start immediately on Western Canada's first iron and steel smelter at Kimberley, B.C. The smelter will be the first stage in an integrated iron and steel operation costing in excess of $20 million.

It will produce pig-iron, steel ingots and rolled steel products. Its capacity will be more than 100,000 tons of steel per year. It will employ over 200 men.

The first stage will be sintering and furnace-feed facilities for a capacity of 100,000 tons of steel per year and one electric furnace of capacity of 36,500 tons of pig-iron per year, with production scheduled for early 1961.

A second larger furnace and oxygen blown converters for the production of steel ingots together with fabricating facilities will follow in the near future.

The Company's reserves of iron tailings from the Sullivan Mine at Kimberley now amount to 15,000,000 tons of recoverable iron. This raw material will be available to the new project in the form of a high-grade iron oxide containing over 60 per cent iron. These iron reserves, the company's power resources on the Kootenay and the Pend-d'Oreille river, the proximity of coal, coke and limestone in the Crowsnest Pass Area, constitute a unique combination of the materials needed for electrothermic production of iron and steel.

The Consolidated Mining and Smelting Company announced in March it will build a $5 million plant at Calgary to produce urea, a chemical which has fertilizer, animal feed and industrial uses. Completion is scheduled for mid-1960.

B.A. Oil Expansion

British American oil will expand the capacity of its Nevis, Alberta gas conservation plant from 15 to 25 million cubic feet of raw gas daily. The plant will process the B-A and Imperial Oil share of production from the nearby Nevis wet gas field.

The expansion will include inlet facilities, amine gas treater, amine liquid treater, refrigeration units, liquid treating and fractionation units, sulphur recovery and boiler plants.

Contracts have been awarded to Poole-Pritchard for construction of the sulphur and boiler facilities, and to Brown and Roote for construction of the hydro-carbon facilities. The expansion is scheduled for completion this fall.

Partnership in Technology

Canadian Vickers Limited, Montreal, have come to agreement with an American company, to fabricate in Montreal, and deliver throughout Canada, materials developed by Knapp Mills Incorporated, New York City.

Vickers will also produce diverse chemical processing equipment, for use where highly corrosive liquors or chemicals must be contained or where radioactive corrosives must be processed and shielded.

Canadian Engineers in Pakistan

The Warsak hydro-electric power project in Pakistan, located on the Kabul River, consists of four hydro-electric generating units, each with a capacity of 55,000 horsepower. It will supply energy to a 45,000 square mile region, and will irrigate 100,000 acres of territory.

H. G. Acres, consulting engineers of Niagara Falls, Ont., are doing the engineering. Construction started in the fall of 1955, and now employs 156 Canadians and 10,400 Pakistani. Canada's contribution to the project under the Colombo Plan is reported to be $36 million.

Photo: Sam Tata

Her Majesty

QUEEN ELIZABETH II

and

PRESIDENT EISENHOWER

perform the opening ceremony for

THE ST. LAWRENCE SEAWAY

JUNE 26, 1959

Photos by courtesy Canadian National Railways

C.N.R. Photo

The Seaway. First Month of Operation

During May, 1959, the first complete month of operation of the St. Lawrence Seaway, 2,243,450 tons of cargo were carried through the St. Lawrence River canals, according to a preliminary statement of toll traffic issued by the Canadian and United States Seaway authorities. This volume of cargo was being transported by 980 vessels, the aggregate gross registered tonnage of which was 2,898,800. As compared with May 1958, when the 14-foot canals were in operation, the increase in cargo was 741,360 tons, or 49 per cent.

Listed in the first table are the cargo statistics for the month of May and cumulative from the opening of navigation:

ST. LAWRENCE SEAWAY—MONTREAL TO AND FROM LAKE ONTARIO
(tons, 2000 lbs.)

May, 1959	*Upbound*	*Downbound*	*Total*
Bulk cargo	700,500	1,300,950	2,001,450
General cargo	84,700	157,300	242.000
Total cargo	785,200	1,458,250	2,243,450
May, 1958			
Total cargo	457,593	1,044,497	1,502,090
Increase %	71.5	39.6	49.3
Navigation Season— April and May, 1959			
Bulk cargo	812,006	1,507,950	2,319,956
General cargo	124,856	231,900	356,756
Total cargo	936,862	1,739,850	2,676,712
April and May, 1958			
Total cargo	615,017	1,479,658	2,094,675
Increase %	52.3	17.6	27.8

During April this year, traffic on the Welland Canal was well below normal due to the later opening, and the persistence for some weeks of ice in the upper lakes. This situation has had an unfavourable influence on the comparison of the cumulative figures for 1959, as compared with those for the previous year.

To the end of May this year, 1370 vessels had entered the canal, gross registered tonnage being 5,740,305.

The cumulative figures reflect the later opening of navigation in 1959. To the end of May this year, 1173 vessels, having gross registered tonnage of 3,449,325, had entered the new Seaway canals.

WELLAND CANAL
(tons, 2,000 lbs.)

May, 1959	*Upbound*	*Downbound*	*Total*
Bulk cargo	636,100	2,255,300	2,891,400
General cargo	45,150	160,100	205,250
Total cargo	681,250	2,415,400	3,096,650
May, 1953			
Total cargo	528,325	2,212,640	2,740,965
Increase %	28.9	9.2	13.0
Navigation Season— April and May, 1959			
Bulk cargo	859,052	3,045,800	3,904,852
General cargo	70,713	250,750	321,463
Total cargo	929,765	3,296,550	4,226,315
April and May, 1958			
Total cargo	776,151	3,336,516	4,112,667
Increase %	19.8	—1.2	2.8

Welland Canal

Cargo tonnage for the Welland Canal for May, 1959, was 3,096,650, exceeding that of the corresponding month last year by 355,685 tons, or 13%. The number of vessels which entered the canal was 1022, of 4,102,000 gross registered tons.

The cargo figures for the month of May, are listed in the second table, with cumulative figures from the opening of navigation.

University News

University of British Columbia

Prof. David M. Myers, head of the department of electrical engineering at the University of Sydney, Australia, has been appointed dean of the faculty of applied science of the University of British Columbia.

Prof. Myers will take up his duties on January 1, 1960. He succeeds Dr. Henry C. Gunning, who is now a consulting geologist for the Anglo-American Corporation in Africa.

Prof. Myers is a native of Australia, and a graduate in engineering from University of Sydney. In 1938 he was awarded the degree of doctor of science in engineering for contributions to the science of computing. Meanwhile he had done post-graduate work in Manchester, England, and at Oxford University. From 1939 until 1949 he worked with the Australian National Standards laboratory, in the electrotechnology division of the Council for Scientific and Industrial Research. He joined the University of Sydney in 1949. He was president of the Australian Institution of engineers in 1958.

Carleton University

Dr. D. F. Coates, M.E.I.C., director of the School of Engineering, Carleton University, went into industry in June.

His successor at the University is Dr. Ruptash, B. Eng., M.S., Ph.D. from Rensselaer Polytechnical Institute, Troy, N.Y.

Dr. Ruptash is originally from Alberta, a graduate of the University of Alberta. He obtained masters and doctorate degrees at the University of Toronto in aeronautical engineering. He taught at the University of Wichita before going to Rensselaer.

This September the University is to move to the new campus on the Rideau River, where the third year of the engineering course will be offered for the first time.

University of Alberta

A degree course in mechanical engineering is to be offered by the University of Alberta. The first class will graduate in 1960. Dr. George Ford, M.E.I.C., graduate of Alberta, will head the new department. Dr. Ford received a Ph.D. degree in mechanical engineering at Stanford university in 1948, specializing in the field of applied mechanics; he joined the staff of the university in 1942. Two years ago he was named professor of applied mechanics.

The decision to establish a department was made after an exhaustive study to determine the need for such a new course and of modern trends of university curricula in this field.

The work of the new department will be centred around two major areas of specialization, applied mechanics and the basic science of thermodynamics; heat transfer theory, fluid mechanics and the applications of these to the design of mechanical equipment, will be included in the thermodynamics area, while statics and dynamics, vibrations, advanced strength of materials, elasticity and application of these basic sciences to machine design problems will be included in the applied mechanics field.

Other staff members will include D. Panar and D. W. Sadler and W. Johnson and C. M. Rodkiewicz, Dr. J. Duby and J. S. Kennedy. Students will be admitted to the course at the beginning of their third year. The first such group was accepted in September 1958.

McMaster University

The University begins a new phase this fall with the opening of the new engineering building. Construction of the building was completed in early May and represents the largest single project in the university's $13 million expansion program. Degree courses in engineering were first offered at McMaster two years ago when enrolment was restricted to 50 students per year. The new building is designed to handle a first-year enrolment of 170 students and a total student body of 550 in all years of engineering. Four-year degree courses are offered in chemical, electrical, mechanical and metallurgical engineering and in engineering physics. Civil engineering will be added this fall.

Highway Developments

Standards for Traffic Control Devices

The Joint Committee on Uniform Traffic Control Devices for Canada, meeting in Ottawa early in May, agreed on more than 200 sign standards, as well as standard signals and procedure. These standards will be published in a manual by Canadian Good Roads Association this year and implementation by governments is expected to follow. Standardization from coast to coast has obvious advantages.

Two features stressed are: visual impact of signs, and extensive use of graphic symbols. Sign wordage is greatly reduced. Striking examples are those signs prohibiting turns — black arrows enclosed in green circles, pointing out the direction in which traffic may proceed. Written messages will be included in the signs only until drivers have had a chance to become familiar with them. The signs are larger than those now in use and considered more striking because of the arrow symbols. There is a symbolic, five sided school house sign. The Trans-Canada Highway will be marked with a white maple leaf on a green background. There is also a civil defence route marker.

The manual recommends standardization of all traffic signs according to size, shape, colour, dimensions, symbols, wording and lettering. The new signs will have dimensions that have multiples of six. They are classified according to functions they fill: regulatory signs, warning signs and guide signs.

The manual contains the first national code for the design and use of traffic signs, signals and pavement markings ever proposed in Canada. The committee, established by C.G.R.A. in co-operation with the Institute of Traffic Engineers was supported by the ten provincial governments, eleven municipalities, agencies of the federal government and several national associations. Ninety-seven traffic men worked for three and a half years on the standards.

Alberta Highway Program

The province of Alberta has voted $32.5 million dollars for main highway construction, $3 million to complete the Trans-Canada Highway and $4 million to commence re-construction of the Mackenzie Highway. Federal government co-operation in the last two items is expected.

One of the major projects being undertaken in this year's program is the continuation of the divided four lane highway south of Nisku. The divided four lane highway completed last year between Airdrie and south of Red Deer is considered one of the most modern highways on the continent.

(Canadian Developments are Continued on Page 139)

INTERNATIONAL NEWS

CZECHOSLOVAKIA

THE INTERNATIONAL TRADE FAIR to be held at Brno, September 5 to 20, 1959 will have engineering exhibits from thirty countries. Many firms whose names are well known internationally will be represented, while other exhibits will be collective or national efforts.

Czechoslovakia's engineering industry has become the foremost of its industries, having developed most quickly since 1945.

Some noteworthy anniversaries being celebrated this year are: 100 years of the SKODA trade-mark; the 145th anniversary of the first Brno Engineering Works; seventieth anniversary of the engineering works at Kralovo Pole.

ITALY-FRANCE

THE MONT BLANC TUNNEL has been under construction since last autumn, and is to be finished in 1961.

To a point 8,200 feet below the summit of Mont Blanc, the tunnel will be driven four miles from Entreves in Italy and three miles from Chamonix in France. Tunnelling, starting at 4,631 ft. above sea level at Entreves, will fall steadily at a gradient of 0.25 per cent; from 4,179 ft. at Chamonix it will rise at 2.4 per cent; the two gradients will meet at 4,583 ft., near the centre of the mountain.

Last April, the face was advancing at about 13 ft. a day from the Italian side. Drills are operated from a three-storey jumbo.

The excavated section will be 861 sq. ft., and the finished section will be 775 sq. ft. The road surface will be reinforced concrete, with width of 23 ft., built 11 ft. above the invert of the driven tunnel. On both sides of the road there will be a pavement 27½ in. wide and 8 in. above the road level.

Other facilities will be 16-ft. long lay-bys at every thousand feet, man-size "escapes" at 330 ft. intervals, telephone links with tunnel entrances, international road signs, illumination controlled by photo-electric cells, good ventilation.

Two pipelines under the road will carry new telephone and telegraphic links between Italy and France.

At completion in 1961, the Italian and French companies responsible for the project will form one company of equal holdings to handle the administration of the tunnel for 70 years. Then it will become the joint property of France and Italy. The total cost for the project is £11.7 million.

The 7-mile route will cut the Paris-Turin and Paris-Milan routes by 137 and 194 miles respectively. It is expected to become a major industrial and a popular tourist route between Northern Europe and the Mediterranean.

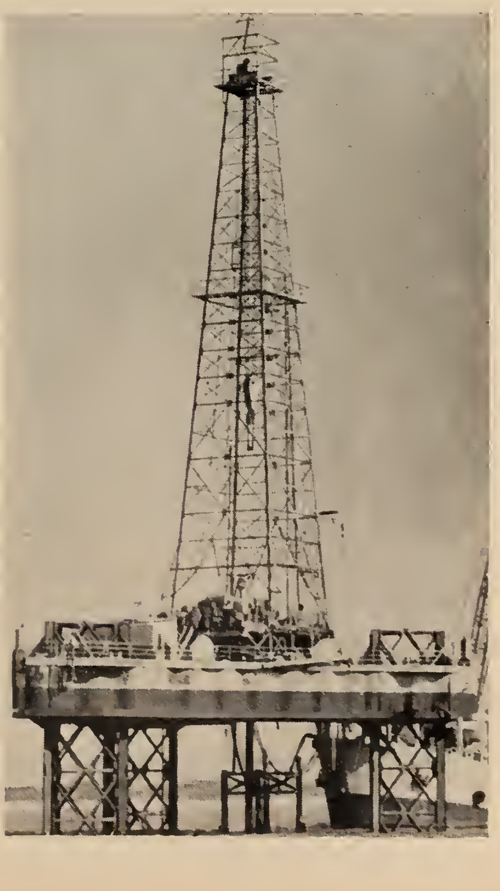
Tolls will be levied on each vehicle. Estimated annual traffic is 264,000 cars, 24,000 coaches, 49,000 motor bicycles and 15,000 trucks, together carrying 1,500,000 passengers and 75,000 tons of freight.

Abstracted from *Engineering*, April 17, 1959

USSR

ATOMIC ELECTRIC POWER, G. V. Yermakov, Chief Engineer of the Atomic Power Administration of the USSR Ministry of Electric Power Station Construction, in an interview with a Moscow correspondent said that the first section of the second atomic, electric power plant in the Soviet Union began operation in September 1958. The first section has a

A 1000-TON "PORTABLE ISLAND" on a tow-voyage across the Atlantic from the marine facilities of R. G. Letourneau, Inc., Vicksburg, Miss., U.S.A., travelled through 75-foot seas at times. It was installed by the Italian company SAIPEM off the coast of Gela, Sicily, in the Mediterranean, and is used to drill for off shore oil. The triangular hull measures 120 ft. by 115 ft. with a depth of 15 ft. The island can raise itself above the water.



capacity of 100,000 kw. and the station's total capacity will be 600,000 kw.

The third atomic electric power plant is going up in the Urals. It is based on the idea of producing super-heated steam by the reactor itself. The uranium-graphite reactor here has two groups of working channels. The super-heated steam goes to the turbine straight from the reactor. And the efficiency of the installation reaches 37 per cent.

The designed capacity of the fourth atomic electric power plant which is going up in Voronezh region is 420,000 kw. It will have two double-water circuit reactors. These reactors will use ordinary water at a pressure of 100 atm. as a neutron moderator rather than graphite.

The fifth atomic plant, of a similar type, will be erected in Leningrad region. In addition, fast neutron reactors are being designed in the Soviet Union, with the coefficient of fuel reproduction exceeding 1. A 50,000-kw plant of this type will be built on the Volga.

In the construction of atomic power plants great attention is paid to biological protection which absorbs the harmful radiation. The site is selected on ground containing thick layers of waterproof clay. Such conditions prevent radio-active substances from the underground installations from polluting local water streams. The sites are fenced off from residential sections and industrial enterprises by a sanitary protective zone which is an additional guarantee of safety for the population. The walls, floor, and ceiling of the main hall of atomic stations are made of solid concrete up to three metres (10 feet) in thickness. Simultaneously with the concrete work, large, metal biological protection structures—steel doors and iron protective slab-plates — are installed.

JAPAN

TOKYO'S NEW TV TOWER is 1,092 feet high. This new landmark was completed at Shiba Park in 1958 for the Japan Television Tower Company, at a cost of $7.5 million. It is topped by a 246-foot television antenna.

Because Japan is subject to frequent earthquakes and typhoons, the tower's stability under these hazards was planned by Dr. Tachu Naito, professor emeritus of Tokyo's Waseda University School of Technology.

Its primary purpose is to act as a platform for multi-service antenna for transmission of electric waves in a variety of frequencies. As many as six TV stations and 58 radio stations are to make use of the antenna unit. In addition police and fire departments and newspapers are expected to use the tower for radio communications.

ATOMIC ELECTRIC POWER GENERATING PROGRAM will be launched under a dual system involving British and American reactors.

The Japan Atomic Power Co. will buy an improved British Calder Hall type of reactor of 150,000 kilowatt capacity.

A 10,000-kw. test power reactor has been ordered from the General Electric Company for installation at Tomai-mura, in Ibaraki Prefecture, the Japanese Atomic Energy Research Institute has announced.

Work was to start on the reactor in April. It will cost about $8.6 million, and will be fueled by enriched uranium to be imported from the United States.

THE NETHERLANDS

COOPERATION IN MANUFACTURE OF PLASTICS is planned by Dutch and British interests. What is being considered is the joint foundation in the Netherlands of an enterprise for the manufacture of urea formaldehyde moulding powders, melamine formaldehyde moulding powders, urea resins and melamine resins.

COLOUR TELEVISION apparatus for medical purposes is being supplied by N. V. Philips' Gloeilampenfabrieken to the pharmaceutical firm of Smith, Kline and French, Philadelphia, U.S.A. The installation consists of a combination of three television projectors each of which reproduces on the screen one of the basic colours red, green and blue. The projection of these three colours over each other results in a perfectly accurate colour picture it is said.

THE LEADING HOISTING GEAR and conveyor factory of the country, N. V. Machinefabriek Hensen, is to build a new engineering works.

The manufacturing program now comprises the construction of various types of hoisting gear and conveyor plants such as cranes for shipbuilding yards, luffing cranes for harbours and various other types of crane, longitudinal and transverse slipways, sluices and barrages with the appurtenant mechanical and electrical operating machinery, and passenger and goods lifts.

THE METAL INDUSTRY has succeeded in the last five years in increasing its production-apparatus regularly. About thirty percent of the Dutch labour force now works in this branch of industry and the same percentage applies to the part the industry plays in the total Dutch industrial production.

UNITED STATES

DIRECT CONVERSION of nuclear reactor energy into electric power was reported on April 7, 1959, by The University of Michigan and Los Alamos (N.M.) Scientific Laboratory.

Robert W. Pidd, professor of physics at The University of Michigan, said the process would cut by perhaps one-half the present cost of building power reactors. It would also tremendously reduce fuel deadweight loads now necessary to propel a rocket into space and enable satellites to have a small but comparatively powerful and long lasting source of electricity with which to telemeter data back to earth. The process would also have great significance in submarine propulsion.

Electric power is obtained from a nuclear reactor containing a uranium carbide source surrounded by a plasma or electrified gas made from cesium. When the reactor is turned on, atomic fission causes the uranium to have such an energy release that it turns white hot. At this temperature a large electric current is produced and is then transmitted by the gas to a collector from which it can be put into use. The technique is called a plasma thermocouple. It eliminates virtually all but the nuclear reactor in the production of electric power from fission. Boilers, turbines, gas condensers and dynamos will not be necessary. But it will be some time before a commercial reactor could be constructed.

The simple device consists of: the source of power, a rod about ¼-in. in diameter and ¾-in. long, containing uranium carbide; this is suspended in the centre of the small cell and surrounded by cesium gas. When the assembly is lowered into the core of a reactor, the neutron flux activates uranium fission heating in the centre of the can, while the flow of reactor coolant around the outside of the can drops the temperature of the cesium plasma. The essential requirements of a thermocouple thus are met, and electricity is produced.

THE SEVENTY-THIRD ANNUAL GENERAL MEETING

THE TORONTO BRANCH was host for the seventy-third annual meeting of The Engineering Institute of Canada, June 8-9-10. Members, their wives, and guests of the Institute in the Queen City found nothing lacking in the hospitality extended by the Branch chairman, Professor A. C. Davidson, and Toronto officers and members.

The amenities of the improved Royal York Hotel, with its attractive new public rooms named and decorated after the Provinces and Territories of Canada, were especially welcome in view of the extreme heat out of doors. Moreover the busy schedule was itself more than sufficient inducement to remain inside. The coordination of Institute business, professional discussion and social events into a program of such variety and interest reflects great credit on the Toronto Committee, under the chairmanship of Whit Davis. Mrs. W. A. Hutchison and Mrs. A. C. Davidson organized the ladies' program.

Each morning for the ladies there was the coffee get-together which is a popular feature of the annual meetings, and on Monday this was followed by a morning drive around the city, lunch at The Old Mill, and an afternoon visit to the renowned James Gardens and Hyde Park Gardens. On Tuesday the ladies lunched at the Royal Canadian Yacht Club, where a bridge demonstration was afterwards arranged for them.

The ladies also paid a conducted visit to the exhibit specially installed in the hotel for this meeting by Atomic Energy of Canada Limited, and many of them were present at the film "Atomic Energy in Canada" which was shown in the ballroom on Sunday evening.

The Program

The Committee on Confederation met on Saturday afternoon and reported to Council the following day. Other Institute business was taken up on Sunday morning when the Branch Officers convened. Delegates and observers from all parts of Canada attended this conference to discuss ways and means of improving service to the Branches and cooperation between them throughout the country.

Council also met on Sunday, and the Committee on Technical Operations assembled in the afternoon. The Annual General Meeting was held on Monday morning, and the following day the new Council of the Institute met for the first time. A report on the Annual General Meeting will appear in an early issue.

The Committee on Engineering Education and the Students' Conference both assembled on Monday. Many of the out-of-town students were accommodated at Hart House, where University of Toronto students entertained student delegates to dinner on Sunday evening.

Authors' Breakfasts each day provided an opportunity for the authors of technical papers to meet the chairmen who were to preside at their sessions. Thirty-nine technical papers were presented, and on Wednesday the final session was devoted to a panel discussion on the economic aspects of the St. Lawrence Seaway. For the first time in Institute history, the technical program was organized and run by the Committee on Technical Operations, and consensus was that their efforts were successful and well appreciated.

At dinner on Monday, June 8th, the office of president of the Institute for 1959-60 was given into the hands of John Jeffery Hanna of Calgary by the retiring president, Kenneth F. Tupper of Toronto.

The inauguration of a National Committee on Professional Development Programs was marked on Tuesday when this committee assembled for the first time at an Annual General Meeting.

The Association of Consulting Engineers of Canada followed their custom of associating their meeting with that of the Institute, and held their annual meeting and annual dinner on Tuesday.

At luncheon on Wednesday President K. F. Tupper presented medals, prizes and certificates of honorary membership to engineers representing practically every area of Canada.

The annual banquet on Wednesday evening, with K. F. Tupper presiding, was followed by a presidents' informal reception and the annual dance. The new president, vice-presidents and councillors of the Institute were formally introduced at the banquet, in the presence of representaitves of all three Canadian Services and of eighteen Canadian and American sister societies. His Worship, Nathan Phillips, Mayor of Toronto, was present at the banquet with Mrs. Phillips as honoured guests of the Institute.

President Tupper also announced the retirement of Miss May McLaren, a senior member of the Headquarters secretarial staff, who is leaving the Institute at the end of June after an association of more than forty years. On hearing this announcement all present rose and gave Miss McLaren a standing ovation.

Quo Vadis?

The wit that framed the observations of Professor Marcus Long, speaker at the banquet, served only to sharpen the focus of his appeal for some attention to the humanities in the education of the engineer. The choice of a distinguished philosopher to speak on this occasion epitomized the spirit of the 1959 meeting, and his wisdom evoked that of other voices on the preceding days. On Monday Dr. Tupper had suggested that as we build and staff the schools of engineering the schools of philosophy should also be enlarged. Earlier still, at the very outset of the meet-

(Continued on page 142)

C.P.R. President, N. R. Crump with Dr. Tupper and Dr. Garnet Page.

The Toronto Committee. Left to right: G. F. R. Norton, Committee Secretary, C. E. Potter, Finance, A. C. Davidson, Chairman, Toronto Branch, M. P. Whelen, Committee vice-chairman, W. A. Bentley, D. R. Abbey, E. R. Davis, C. MacInnis, H. B. Tryhorn, B. Hardcastle, A. Missakian. Inset: D. D. Whitson.

EIC

ANNUAL MEETING

TORONTO 1959

At dinner on Monday evening retiring President K. F. Tupper delivered his farewell address and formally handed over the gavel to President John Jeffrey Hanna.

The new Council holds its first meeting. Below: the retiring Council.

Dr. Lillian Gilbreth with Dagny Vidinsh, a 1959 engineering graduate and at 21 almost the youngest student delegate.

The newly-formed Professional Development Programs Committee. Left to right: J. Walsworth; W. E. Lardner; A. Missakian; K. R. Crean; E. T. W. Bailey (Chairman); W. A. M. Filer; W. O'Reilley; D. Stephenson; M. Truemner; K. Anderson; H. Lightbody.

HONOURS AND AWARDS, 1959

These awards were presented during the annual meeting to those recipients who could be present.

HONORARY MEMBERSHIPS

Randolphe William Diamond, Trail, B.C.
David Arnold Keys, Deep River, Ont.
Roy Aubrey Spencer, Saskatoon, Sask.
John Bertram Stirling, Montreal, Que.
James Alfred Vance, Woodstock, Ont.

SIR JOHN KENNEDY MEDAL

Richard Edgar Heartz, M.E.I.C., Montreal, Que.

JULIAN C. SMITH MEDALS

Norris Roy Crump, M.E.I.C., Montreal, Que.
J. Alphonse Ouimet, M.E.I.C., Ottawa, Ont.

GZOWSKI MEDAL

Raymond Edward Grout, Montreal, Que.
John Arthur Thomas, Montreal, Que.

LEONARD MEDAL

Lazure Eruant Djingheuzian, Ottawa, Ont.

PLUMMER MEDAL

Robert Owen King, M.E.I.C., Ottawa, Ont.

DUGGAN MEDAL AND PRIZE

William Cumming Leith, Montreal, Que.

ROSS MEDAL

Frederic Lewis Lawton, M.E.I.C., Montreal, Que.

ROBERT W. ANGUS MEDAL

Lawrence Milton Boyd, M.E.I.C., Montreal, Que.
Walter Scott McIlquham, M.E.I.C., Montreal, Que.

The Branch Officers met under the chairmanship of Professor A. C. Davidson.

Retiring President K. F. Tupper chats with D. O. Turnbull, President of the Canadian Council of Professional Engineers.

Rendezvous for the banquet. Left to right: Mrs. Marcus Long; E. R. Davis; Mrs. K. F. Tupper; Professor Long; Mrs. Davis; Dr. Tupper.

Conversation piece: Left to right: Mrs. E. C. Luke; Mrs. Garnet Page; Mrs. K. F. Tupper; Mrs. J. J. Hanna.

Dr. Tupper with representatives of the three Services: Colonel W. A. Capelle of the Canadian Army; Group Captain C. L. Ingles, R.C.A.F.; and Commodore H. G. Burchell, R.C.N.

His Worship, The Mayor with the two presidents. Left to right: the new president and Mrs. J. J. Hanna; Dr. and Mrs. K. F. Tupper; Mr. and Mrs. Nathan Phillips.

ASME Honours Canadian

H. S. Van Patter, M.E.I.C., vice-president and director of Dominion Engineering Works Limited, Montreal, recently was elected a Fellow of the American Society of Mechanical Engineers.

To mark the occasion, a luncheon was held at the University Club, Montreal, on April 22, with Dr. R. E. Heartz, M.E.I.C., HON. MEM. A.S.M.E., in the chair. Dr. L. Austin Wright, HON. M.E.I.C., MEM. A.S.M.E., presented Mr. Van Patter to the meeting and outlined his long connection and many activities with The Engineering Institute of Canada.

Logan Kerr, M.E.I.C., of Philadelphia, himself a Fellow of A.S.M.E., gave a short account of Mr. Van Patter's accomplishments in the field of engineering and of administration, pointing out that during the period of his services with the Dominion Engineering Works as design engineer and administrator the company has produced 13.5 million horsepower of hydraulic turbines. He referred also to the valuable experimental work done by Mr. Van Patter on turbine pumps and cavitation.

Dr. Heartz then presented the certificate of Fellowship to Mr. Van Patter, making reference to the many satisfactory transactions he had had with Mr. Van Patter and his company.

In response, Mr. Van Patter disclaimed the credit for the many achievements which had been mentioned by the three speakers. He gave credit for all of these to the company and to the many excellent people who had been associated with him throughout his almost forty years of connection with the Dominion Engineering Works Limited.

In conclusion, the meeting expressed to Dr. Heartz its appreciation of his thoughtfulness in bringing the group together to mark this interesting occasion.

S. Logan Kerr, M.E.I.C., and H. S. Van Patter, M.E.I.C., and Dr. R. E. Heartz, M.E.I.C.

The Royal Canadian Engineer Museum at Camp Chilliwack, B.C.

An abstract of an article by Capt. J. S. McGivern, S.J., M.B.E., C.D. R.C.A.Ch.C.(R.C.)

When the Royal Canadian Engineer Museum placed a military exhibit, or museum in miniature, in the Pacific National Exhibition last year, many people wondered about the parent Museum. This was not very surprising, for the history of this museum goes no further back than July, 1956. At that time, *The Canadian Sapper* headline read, "R.C.E. Museum Becomes a Reality".

It had been a long-felt want and many proposals and plans had in the past been made. But it was not until July 1956 that more strenuous efforts could be exerted. Under the encouragement of Colonel R. J. Carson, C.D., now commandant of the School of Military Engineering, and the enthusiastic cooperation of many other officers, plans for the Museum progressed rapidly. At that time a Museum Board was established, consisting of Col. Carson, Major Burgoin, Capt. Blake, and R.S.M. Sininger.

The first place set aside for the start of the Museum was the former Roman Catholic Chapel. The Army had built a new chapel for Catholic personnel and on August 15, 1956, the new building was taken over and the first service held there. This left the old chapel available for the R.C.E. Museum.

One of the first projects of the Museum was to try to illustrate the motto of the Royal Canadian Engineers: OBIQUE QUO FAS ET GLORIA DUCUNT. As the word 'FAS' normally in its original latin means 'divine right', it was considered appropriate to combine the old R.C. Chapel and the first Protestant altar used in Camp Chilliwack, as the shrine on which to place the Books of Memory containing the names of those Engineers who died during World Wars I and II. The altar was flanked with the Corps Flag, the Union Jack, the Canadian Ensign, and the last flag flown over the Royal Canadian Engineers' ships. In the centre, above the altar, the picture of Her Majesty Queen Elizabeth was placed.

Soon after this, exhibits began to come in. The Museum was finally set up in January 1957 in the old chapel and was opened to the Corps of the Royal Canadian Engineers by the Honorary Colonel Commandant of the Corps, Brigadier J. L. Melville, C.B.E., M.C., E.D., in May of that year. On August 8, 1958, Sir Ouvry L. Roberts, G.C.B., K.B.E., D.S.O., former Quartermaster General of the British Army and an Honorary Colonel, Commandant of the British Royal Engineers, opened the Museum to the public. Present on that occasion were a number of descendants of the British Royal Engineers who pioneered in British Columbia a hundred years before. The Museum is now open to the public every Wednesday evening, from seven to nine o'clock, and on the first and third Sundays of each month from three to four-thirty. The number of visitors is steady but by no means extraordinary as yet.

The biggest problem is that of continued growth. Unless it continues to have new and interesting exhibits and a place to show them, the R.C.E. Museum could become a stagnant and dormant thing. However, it is still continuing to receive new and interesting material from both the First and Second World Wars, though the influx is not as great as in the earlier days.

The R.C.E. Museum was formally opened by General Sir Ouvry Roberts, left, with Major A. S. Millen aud Col. M. Turner (at back).

However, we know there must be a great deal more material kicking around in attics or buried in trunks. We are particularly looking for badges, regimental flashes, medals and uniforms. The writer would like to urge everybody to continue to help us expand. If you find things that might interest us, please do not hesitate to contact the Museum staff.

One of the best helpers in the Museum is Mrs. Bateson, who has a special project at the moment — a Sergeant's Exhibit. It consists of uniforms and hats or caps of sergeants during the past sixty or sixty-five years.

Recently the Museum was presented with a complete set of Bruce Bairnsfather's "Fragments of France". There are also two original drawings of this World War I artist.

Brigadier J. B. Bishop, O.B.E., C.D., has commented "A military museum, over and above the intangible values of preserving the history and traditions of the Army, provides an educational value to all military personnel in the maintenance and display of equipment, material, and related items which have played a part in the history of the Canadian soldier. They give evidence of technical development, traditions, and an esprit de corps, of an army that has captured the admiration and respect of all nations".

M.E.I.C. at Atlantic Congress

James A. Vance, M.E.I.C., was one of the delegates from Canada to the Atlantic Congress, which was held in London, England in June. Mr. Vance was a member of the Committee on Resources and Underdeveloped Areas in the Atlantic Countries.

The discussions were attended by 650 political and business representatives from the member nations of North Atlantic Treaty Organization.

Chairman and head of the Canadian delegation was Henry Frank Jones, LL.B., M.P.

Consulting Engineers Annual Meeting

The annual general meeting of the Association of Consulting Engineers of Canada took place at the Royal York Hotel, Toronto, on June 9, 1959, the chairman being C. C. Parker, P.Eng., of Hamilton, Ont. Members from all parts of Canada were present and the Consulting Engineers Council of the United States was represented by its president, Ralph M. Westcott, of Los Angeles.

In his report for 1958, Immediate Past-President John G. Frost stated that the Canadian Association of Consulting Engineers has been admitted into the membership of FIDIC, the Federation Internationales des Ingenieurs Conseils.

Among the reports presented was that of the Committee on Tariff of Consulting Fees. Its chairman, Edgar A. Cross, of Toronto, referred to a study being made of fee structures in the various provinces and he expressed the intention to shortly submit proposed revisions which will be designed to more adequately meet the changing conditions in the various fields of consulting practice.

The meeting was followed by the annual dinner of the Association which was attended by members and their wives. Among the guests were Immediate Past President K. F. Tupper and Mrs. Tupper, and President-Elect J. J. Hanna and Mrs. Hanna, Engineering Institute of Canada; Ralph M. Westcott, Los Angeles; Maurice Payette, president, Royal Architectural Institute of Canada; J. E. Harrington, President, Canadian Construction Association, and Mrs. Harrington; A. W. F. McQueen, President, Ontario Association of Professional Engineers, and Mrs. McQueen; R. A. Frigon, Department of Trade and Commerce of Canada; and D. O. Turnbull, President, Canadian Council of Professional Engineers.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

John William Porter, M.E.I.C. died early in 1958 in Winnipeg, Manitoba.

Mr. Porter was born in Aberdeen, Scotland on October 15, 1877 and was educated at Gordon's College, Aberdeen. He served a five year pupilage with P. M. Barnett, chief engineer with the Great North of Scotland Railway.

Mr. Porter came to Canada in 1902 and joined the C.P.R. in Montreal.

In 1905 he became resident engineer with the C.P.R. in Toronto and in 1915 became chief engineer with the Hudson Bay Railway. In later years he was a consulting engineer, with W. C. Arnott & Co., in Winnipeg.

C. D. McAllister, M.E.I.C. of Saint John, N.B., died on March 20, 1959.

Mr. McAllister was with the Federal Department of Public Works where he was assistant chief engineer of the New Brunswick division.

He represented Canada as secretary on the Canadian contingent to the joint U.S.A., Canada committee on the Passemaquoddy hydro power project and was also a warden for the Engineering iron ring ceremony.

Until the time of his death he was active with several community organizations.

Mr. McAllister was a graduate of University of New Brunswick, class of 1918.

W. E. Warburton, M.E.I.C. retired city engineer of Penticton, B.C., died on March 28, 1959.

Born on March 1, 1893 in Charlottetown, P.E.I., he received his engineering education at Kings College, N.S., and at McGill University.

After serving in World War I, from 1914 to 1918, he joined Green Bros. & Burden, B.C. as instrument man. In 1921 he became assistant engineer with Nelson Sewer Construction and from 1925 until 1941 served on various construction projects.

Mr. Warburton opened his own construction company in 1946 and in 1947 became city engineer with the City of Penticton, B.C. where he was until his retirement.

A. R. Holmes, M.E.I.C., died on February 24, 1959, at Windsor, Ont.

Born at Hantsport, N.S. on July 18, 1872, he graduated from King's College, N.S., in 1895, with a bachelor of engineering degree.

After graduating he worked as draftsman and structural engineer with various construction and railway projects.

He was secretary-treasurer for seven years with MacKinnon, Holmes & Company Limited, Sherbrooke, Que. and later, president of Archibald & Holmes Limited, Toronto. He continued to work in engineering in Toronto, latterly with Allward Gouinlock, Architects, and with the Bell Telephone Company. He went to Windsor in 1958.

T. Frederick Francis, M.E.I.C., of Toronto, Ont., died May 8, 1959.

Born in Moncton, N.B., he started his career with the C.P.R. in 1907. He later returned to university and graduated from McGill in 1915 as a civil engineer.

After serving in World War I as a member of the Railway Corps, he returned to Canada and rejoined the C.P.R. where he supervised construction in western Canada.

He was responsible for construction work on the Rogers Pass and Connaught tunnel near Revelstoke.

Mr. Francis retired two years ago as construction engineer with the Ontario Department of Highways. Since his retirement he had been consultant on Trans Canada Highway work near Revelstoke.

Victor S. Chestnut, M.E.I.C. died on April 27, 1959, at St. John, N.B.

Born in Toronto, he received his degree in engineering at Toronto University in 1912. He was employed for five years in construction of the Welland Canal.

From 1919 until 1924 he was on the staff of Saint John Dry Dock Company Limited. He went to Ontario then to work on elevator construction at Midland, and later on the designing staff of the Welland Canal.

In 1930 he returned to Saint John as port engineer. He retired in 1953.

J. N. Stinson, M.E.I.C., died on April 3, 1959, in Ottawa.

Born at Toledo, Ont., he graduated from Queen's University in 1914 with the degree of bachelor of science in civil engineering.

Upon graduation he joined the National Parks Branch of the former Department of Interior. In 1949 he retired from the civil service where he was supervising engineer of the Engineering Division of the Department of Mines and Natural Resources.

George Percival Wilbur, M.E.I.C. died suddenly on May 5th, 1959.

Born at Victoria Harbor, he received his education in Toronto and in 1909 began his career with Polson Iron Works in Toronto.

In 1913 he joined Dominion Bridge Company Limited where he became successively chief draftsman, contracting engineer and sales manager and in 1951 he was elected vice-president and general manager for the company.

He retired from the company in 1956.

Ewart Greig, M.E.I.C. chairman of the board of Union Carbide Canada Limited, died May 18, 1959 in Toronto.

Born and educated in Toronto, Mr. Greig joined the National Carbon Division of Union Carbide in 1919 where he was appointed vice-president and general manager in 1942. Upon formation of Union Carbide Canada Limited in 1954, M. Greig was made first president of the company and was elected board chairman in 1956.

He was active in the management of CKNC in Toronto, one of Canada's first radio stations established by National Carbon in the early 1920's and then taken over by the Canadian Radio Commission.

Arthur John Gayfer, M.E.I.C. died on March 6, 1959, at Kelowna, B.C. He was born on January 25, 1877 at Uxbridge, England. He came to Canada in 1898.

Mr. Gayfer served in Belgium and France during the first world war as a major and as chief engineer of the Twelfth Battalion Light Railway Troops.

After forty-two years of service with the Canadian National Railway Company, he retired in Calgary, before going to Kelowna. His work had been mostly on location and construction of eastern and western lines.

E.I.C Annual General Meeting, 1960

Royal Alexandra Hotel, Winnipeg, Man., May 25-26-27.

Personals

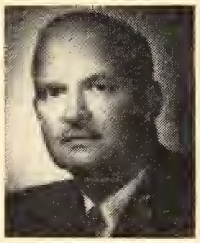
A. E. Cameron, M.E.I.C. (B.Sc., mining, 1913, M.Sc., McGill, 1914, D.Sc., M.I.T. 1926) was awarded the honorary degree of Doctor of Engineering recently at the Nova Scotia Technical College. Dr. Cameron is the former president of N.S.T.C.

J. H. Mowbray Jones, M.E.I.C. (B.A.Sc., mech., Toronto, 1927) received an honorary Doctor of Engineering degree at the recent Nova Scotia Technical College convocation. Mr. Mowbray Jones is vice president of Mersey Paper Company, Liverpool, N.S.

Jack Morris, M.E.I.C. plant manager of Courtaulds (Canada) Limited, Cornwall, Ont., has been elected to the board of directors of the company.

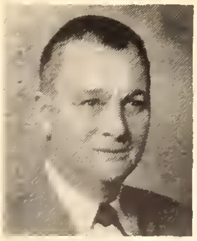
J. W. Macdonald, M.E.I.C. (B.Sc., elec., Nova Scotia, 1931) formerly assistant chief engineer, has been appointed chief engineer of the Nova Scotia Light and Power Company Limited, Halifax, and its subsidiaries.


J. W. MacDonald, M.E.I.C.


Jack Morris, M.E.I.C.

Albert G. Ley, M.E.I.C. (B.Sc., elec., Nova Scotia, 1930) has been made superintendent of the thermal division with the Nova Scotia Light and Power Company Limited, Halifax, N.S.

W. G. Macdonald, M.E.I.C. formerly chief engineer, has been appointed executive engineer with the Nova Scotia Light and Power Company, Limited, Halifax.


Albert G. Ley, M.E.I.C.


W. G. Macdonald, M.E.I.C.

Dominion Bridge Company Limited reorganization has resulted in a number of senior management appointments, including these:

W. Herbison, M.E.I.C. has been appointed works manager in the Montreal Branch.

P. G. A. Brault, M.E.I.C. (B.Sc., McGill, 1921) has been named chief engineer, structural division (Montreal).

C. J. Pimenoff, M.E.I.C. (B.Sc., M.Eng., McGill, 1931, 1932) is assistant chief engineer, structural division (Montreal).

H. J. Leitch, M.E.I.C. (B.Sc., McGill, 1926) has been named sales manager, structural division (Montreal).

A. M. Bain, M.E.I.C. (B.Sc., civil, Manitoba, 1928, M.Sc., McGill, 1929) has been appointed chief engineer, platework division (Montreal).

W. G. Peacock, JR.E.I.C. (B.Eng., civil, McGill, 1949) is appointed sales manager of the platework division (Montreal).

D. J. Lewis, M.E.I.C. (B.Sc., civil, Queen's, 1924) is manager of contracts, platework division (Montreal).

H. L. Ferguson, M.E.I.C. has been appointed chief engineer of the mechanical division.

F. Block, M.E.I.C. (mech. engineer, Vienna, 1921) is chief engineer of the boiler division.

J. M. Dyke, M.E.I.C. (B.A.Sc., mech., Toronto, 1943) is manager of contracts, boiler division.

J. R. MacKay, JR.E.I.C. (B.Eng., mech., McGill, 1951) is in charge of sales of water tube boilers and steam storage schemes in the Boiler Division.

R. M. Robertson, M.E.I.C. (B.Sc., civil, McGill, 1920) manager of operations at Lachine, Que. has retired after many years with the company.

D. E. Perriton, M.E.I.C. (B.Sc., mech., McGill, 1922) has been appointed manager of contracts, for the mechanical division.

Herbert F. Schmelz, M.E.I.C. (Polytechnique Institute of Vienna, Austria, 1936) formerly of Montreal, has been appointed director of engineering for Industrias Metalicas and its allied plants in South America.


George L. Houghton, M.E.I.C.


Ernest F. Wilson, M.E.I.C.

George L. Houghton, M.E.I.C. (Higher Nat. Cert., Mech., 1946) has been elected second vice president of Racey, MacCullum and Associates Limited, Toronto.

Ernest F. Wilson, M.E.I.C. (B.A.Sc., Aeronautical, Toronto, 1949) has been made a representative of Linde Co. division of Union Carbide Canada Ltd., for Toronto and Eastern Ontario.

H. W. H. Casperd, M.E.I.C. (B.Sc., civil, London, 1928) has been appointed chief field engineer with the Foundation of Canada Engineering Corporation Limited, Toronto.

H. G. Ambrose, M.E.I.C. (B.A.Sc., mining, Toronto, 1942) has been appointed assistant general manager of V. D'Ambrosio and Company Limited, Toronto.


H. G. Ambrose, M.E.I.C.


H. W. H. Casperd, M.E.I.C.

Earl Dokken, M.E.I.C. (B.Sc., mech., Saskatchewan, 1944) is general manager of Redi-Mix Ltd, Moose Jaw, Sask., and also president and general manager of Inland Construction Ltd., Moose Jaw.

Kenneth C. Cox, M.E.I.C. (M.Sc., civil, Lehigh, 1939) was recently elected vice-president of Dravo of Canada Limited, Toronto.

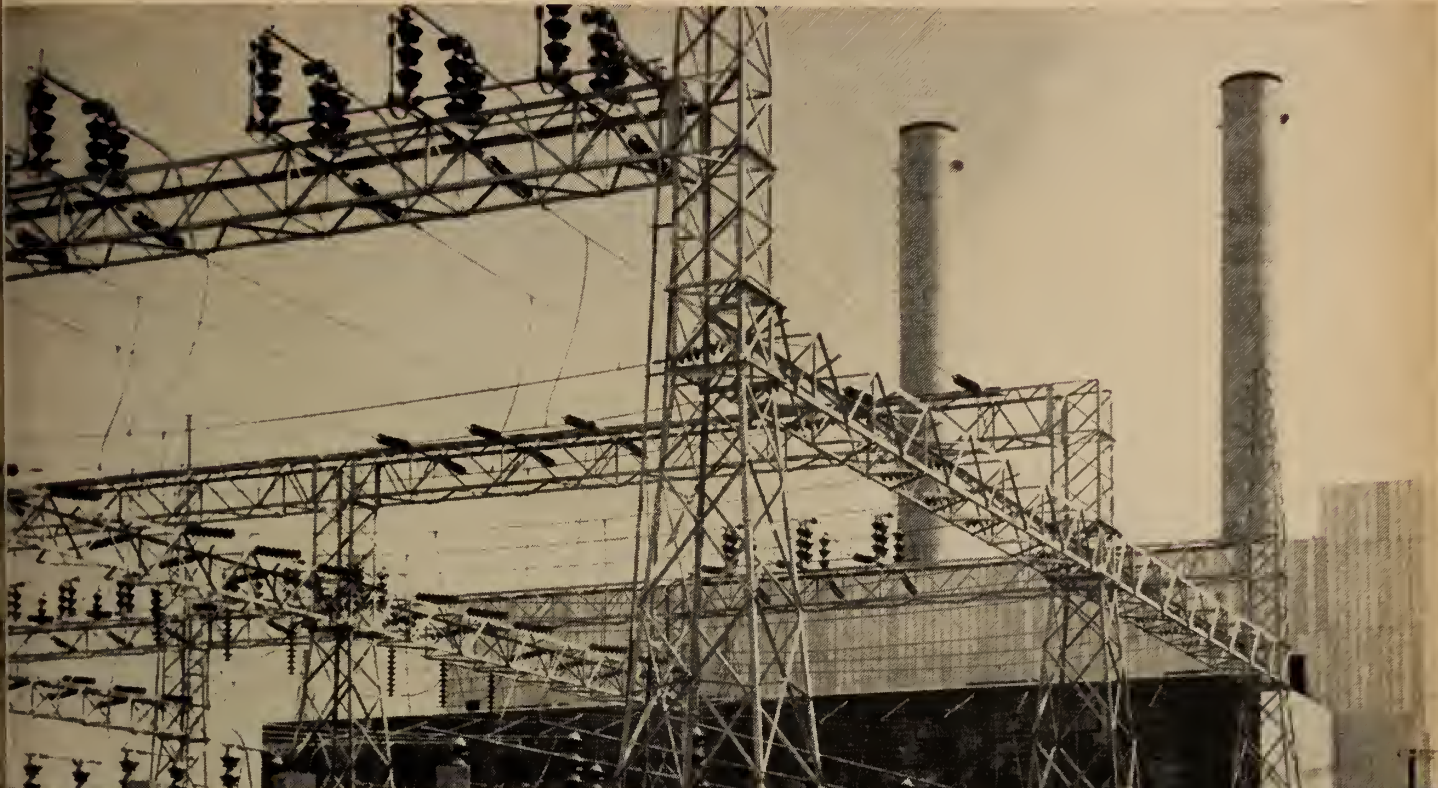

Earl Dokken, M.E.I.C.


Kenneth C. Cox, M.E.I.C.

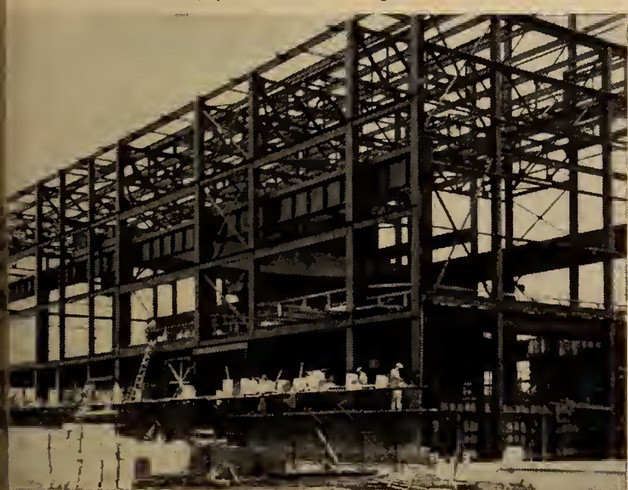
A. K. Piercy, M.E.I.C. (B.Sc., mech., Saskatchewan, 1942) has been appointed chief engineer of Alpha Manufacturing Company Limited, Winnipeg.

William L. Fraser, M.E.I.C. (B.A. Dalhousie, 1915, B.Sc., McGill, 1917) has been appointed Ontario Hydro's director of the St. Lawrence Power Project.

DOMINION BRIDGE



ba Bridge crews erect and place into position 60″, 48″, 30″ and 24″ pipe for the cooling water.



ork for the main building. All three buildings contain a total of 2100 tons of structural steel.

Brandon generating station switchyard showing galvanized steel structure:

At Brandon Generating Statio

Manitoba Hydro Electric Board's Brandon generating statio has a structural steel frame. The station has increased th system's capacity by 132 M.W. and comprises four 33 M.W hydrogen cooled steam turbo-alternator sets.

For this project, Dominion Bridge fabricated and erecte the structural steel for the principal buildings and Manitob Bridge supplied a considerable amount of the steelwor used throughout the plant.

Contracts included 2100 tons for the powerhouse, adminis tration building and fuel bunkers: approximately 1300 ton of miscellaneous steel structures for use within the buildings a 500 H.P. packaged unit scotch dry back heating boiler extensive steel pipework for the cooling water, and th galvanized steel structures in the switchyard.

MANITOBA BRIDGE

PERSONALS

D. B. Annan, M.E.I.C. (B.Sc., Queen's, 1940) is assistant director of military sales at the De Havilland Aircraft of Canada Ltd, Downsview, Ont.

Kenneth R. Bullock, M.E.I.C. (B.Eng., elec., McGill, 1952) formerly of Ontario has joined the Anaconda Wire & Cable Company, Hastings-on-Hudson, N.Y.

John Greenaway, M.E.I.C. is now application engineer with the Alpha Manufacturing Company Limited, Winnipeg.

G. H. Wood, M.E.I.C. (B.A.Sc., civil, Toronto, 1917) has recently retired as district engineer with the Department of Northern Affairs and National Resources, Ottawa.

A. C. Ridger, M.E.I.C., has been named special assistant, engineering division of Cominco Engineering, Trail, B.C.

N. D. Heaslip, JR.E.I.C. (B.A.Sc., chem., British Columbia, 1951) has been made supervisor of the high explosives department, of Canadian Industries Limited at McMasterville, Que.

R. Keith Jamieson, M.E.I.C. (B.A.Sc., M.Sc., civil, British Columbia, Manitoba, 1952, 1957) has been appointed engineer-Missionary under appointment to Angola, Africa with The Board of Overseas Missions, the United Church of Canada.

R. A. Phillips, M.E.I.C.

J. A. Dubuc, JR.E.I.C.

R. A. Phillips, M.E.I.C. (B.A.Sc., British Columbia, 1939) of Canadian General Electric Company Limited, Montreal is the chairman of the Montreal Branch of the Institute.

J. A. Dubuc, JR.E.I.C. of James H. Wilson Limited, Montreal has been elected chairman of the Montreal Branch of the Institute.

D. G. McKay, JR.E.I.C. (B.Sc., mech., Manitoba, 1949) formerly with Emco Limited, Calgary, Alberta is now self employed as a manufacturers agent in Nanaimo, B.C.

H. W. R. Gibney, JR.E.I.C. (B.A.Sc., mining, British Columbia, 1950) has been appointed method study technician, mines division of The Consolidated Mining and Smelting Company at Kimberly, B.C.

William Fredenburg, JR.E.I.C. (B.A.Sc., mining and geology, Toronto, 1949) field engineer with The General Engineering Company Limited, Toronto, has lately been located at Viburnum, Missouri.

Edger D'Souza, JR.E.I.C. (B.Eng., elec., Syracuse, 1950) has joined Quebec-Telephone in Rimouski, Que., to work in the plant extension group of the engineering department.

Raoul Verret, JR.E.I.C. (B.A.Sc., civil, Polytechnique, 1952) was recently appointed director for European operations for Werner Associates Inc., management consultants, New York.

R. H. Nutt, JR.E.I.C. (B.A.Sc., mech., Toronto, 1952) is working with the Pioneer Saw Limited, Peterborough, Ont. as a project engineer.

Kui Yuen Kwong, JR.E.I.C. (B.Eng., civil, McGill, 1957) has been made structural engineer with Pak C. Kwong, M.Arch., in Hong Kong.

Maurice Malo, JR.E.I.C. (B.Eng., mech., McGill, 1950) is now combustion and development engineer with Volcano Ltd., St. Hyacinthe, Que.

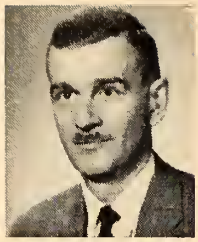
R. J. Kavanagh, JR.E.I.C. (B.Sc., elec., New Brunswick, 1953) lecturer at the University of Toronto has been awarded a National Research Council postdoctorate overseas fellowship at Imperial College, London.

• PERSONALS

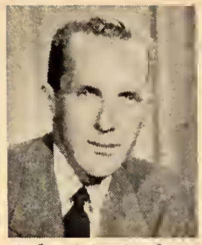
Edward W. Thorne, JR.E.I.C. (mech. eng., I.M.E., 1954) is an engineer with Spade Contractors, London, Ont.

R. M. Dunton, JR.E.I.C., (B.Eng., mech. McGill, 1949) of Dominion Engineering Company Limited, Montreal, has been appointed chief engineer of the press, mining and rubber departments.

K. L. Pinder, JR.E.I.C. (McGill, 1951, 1952, Ph.D., Birmingham, 1954) is in the research department of Dow Chemical of Canada Ltd., Sarnia, Ont.



R. M. Dunton, JR.E.I.C.



John M. Epplett, S.E.I.C.

G. D. McKenzie, JR.E.I.C. (B.Sc., mech., Manitoba, 1957) has become research and development engineer of Alpha Manufacturing Company Limited, Winnipeg.

Reginald S. Wallace, JR.E.I.C. (B.A.Sc., civil, 1956) is a field engineer with the Department of Transport, Air Services Branch, Toronto.

Paul Imbeau, JR.E.I.C. (B.Sc., mech., Laval, 1957) is an industrial engineer with Vincent Casson, P.Eng., industrial engineer and management consultant.

John M. Epplett, S.E.I.C. (B.Sc., civil, Queen's, 1958) is on the sales engineering staff of the bailey bridge department of Contractors Service Limited, Toronto.

Alex Grecoff, S.E.I.C. (B.Eng., civil, N.S.T.S. 1958) is a field engineer with the Pentagon Construction Company, Montreal.

Corrections

Names appearing under these two pictures in the Personals section, May issue, pages 133 and 137 were reversed in error. The pictures are repeated here, correctly captioned:

Max Deitch, JR.E.I.C.

C. K. Lockwood, M.E.I.C.

Mistakes were made also in the setting of names under these pictures in the section "Newly elected officers of the Institute", May issue, pages 127 to 128. The pictures are correctly identified, as follows:

A. S. Mitchell, M.E.I.C.

P. W. Gooch, M.E.I.C.

T. N. Davidson, M.E.I.C.

W. A. Mitchell, M.E.I.C.

NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute

and abstracts of the papers presented at their meetings

CENTRAL B.C.

Report of the Western Field Secretary, A. C. M. Davy, M.E.I.C.

IN PENTICTON ON MAY 1ST there was a joint dinner meeting of the Central B.C. branches of the Institute and the Association of Professional Engineers of B.C. About 30 people were present, some from as far away as Revelstoke and Kamloops.

Some thought has been given to the possibility of holding one or more joint meetings with nearby branches. They have concluded that joint meetings with Vancouver or Vancouver Island branches are not practical, but that a joint meeting with the Kootenay Branch might be worked out. Further study is to be given to this project.

An extremely interesting field trip was being arranged to the Rogers Pass section of the Trans Canada highway in later June. This is described immediately below.

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

A FIELD INSPECTION of the Rogers Pass Route of the Trans Canada Highway in Glacier National Park was planned for June 26.

The party was to go on the Friday morning to Glacier, B.C., have lunch at the Federal Department of Public Works Camp, and then inspect the works and construction in the area.

Returning to Revelstoke, they were to take part in the dedication of a plaque. This is a joint project of the Central B.C. branches of the E.I.C. and the Association of Professional Engineers of B.C. It commemorates the pioneer engineers and especially Major A. B. Rogers, who was in charge of construction of the Canadian Pacific through the mountains, 1880-1885.

Two speakers were scheduled for the dinner meeting, later the same day. They are: P. Schaerer of the National Research Council, on "Avalanche Control", and R. K. Coates, P.Eng., engineer in charge of construction of the T.C.H. through Glacier and Revelstoke National Parks, whose subject is "Location through Rogers Pass".

CORNWALL

H. S. Johnson, JR.E.I.C., *Correspondent*

JOHN T. GEOGHEGAN, finishes division manager, DuPont of Canada Limited, Toronto, spoke at the meeting of June 2, on the subject, "The Hues You Choose and Use".

Colours and qualities of paints were discussed by Mr. Geoghegan. The thin finish on a car is expected to, and usually does, stand up to all extremes of temperature and weather conditions and usage. For best results, the speaker suggested that a reputable brand of paint be used according to the manufacturer's recommendations.

Colour, he said, has a definite psychological effect. The most preferred colours are blue, red and green. Colour can change the character of a room, for instance. Colour is an important factor for purposes of advertising and traffic and safety signs. The visibility and attention values of colours for these purposes is well known.

EASTERN TOWNSHIPS

Jean Bourassa, JR. E.I.C., *Correspondent*

THE ANNUAL MEETING and Ladies' Night took the form of a buffet supper on May 30 at the Club Sociale de Sherbrooke. The meeting was followed by a dance.

The newly elected officers of the branch are: chairman, J. C. Davidson; vice-chairman, J. P. Champagne; councillors, W. K. Baldwin, Michel Normandin and R. V. Planck. The new secretary is A. H. MacLean of Moulton Hill Rd., Lennoxville.

FREDERICTON

John Burrows, M.E.I.C., *Correspondent*

AN INFORMAL GATHERING was held on May 11, 1959 at which the Branch entertained members of the graduating class of the University of New Brunswick.

HAMILTON

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

FIRESTONE TIRE AND RUBBER COMPANY, Hamilton, was host to a group of branch members on May 14, for a guided tour of the tire plant.

An afternoon coffee break was provided in the company cafeteria before the tour commenced. The tour then covered the manufacture of tires from the storage and curing of the raw rubber to the final inspection of the finished product.

Hamilton. J. L. Harbell, R. H. Stevenson, E. W. Hill, C. A. McCurdy, during an inspection visit to Firestone Tire and Rubber Company.

Hamilton officers, R. H. Stevenson, P. J. McNally, and R. C. Mitchell.

AN EXECUTIVE MEETING was held on April 9, 1959. R. H. Stevenson, vice president was appointed chairman to fill the unexpired term of H. E. Seely who had been transferred to Toronto. P. J. McNally was appointed vice-chairman and J. M. Skinner was appointed an executive committee member. At the same meeting three members were appointed to the national committee of the professional development program: W. A. H. Filer, K. R. Crean, and J. A. Walsworth.

LAKEHEAD

G. O. Hansen, JR.E.I.C., *Correspondent*

LEOPOLD NADEAU, general secretary of the Canadian Council of Professional Engineers spoke at the meeting of May

Plated U.F.G. beauty is apparent in these fine products. Case of the Westclox Pocket Ben by Western Clock Company, Ltd., and fishing lures by Lucky Strike Bait Works Ltd. are outstanding examples of low-cost fine finishes obtained with U.F.G. Brass Strip.

Noranda makes an extensive range of copper and brass strip and sheet to meet a wide variety of drawing, spinning, stamping and engineering applications. Because so many different characteristics can be "built into" copper alloys you can meet almost any product or production requirement with ease. Regardless of the material you are now using, it will pay you to discuss your strip and sheet needs with the Man From Noranda... chances are he can show you new ways to use copper alloys to better advantage.

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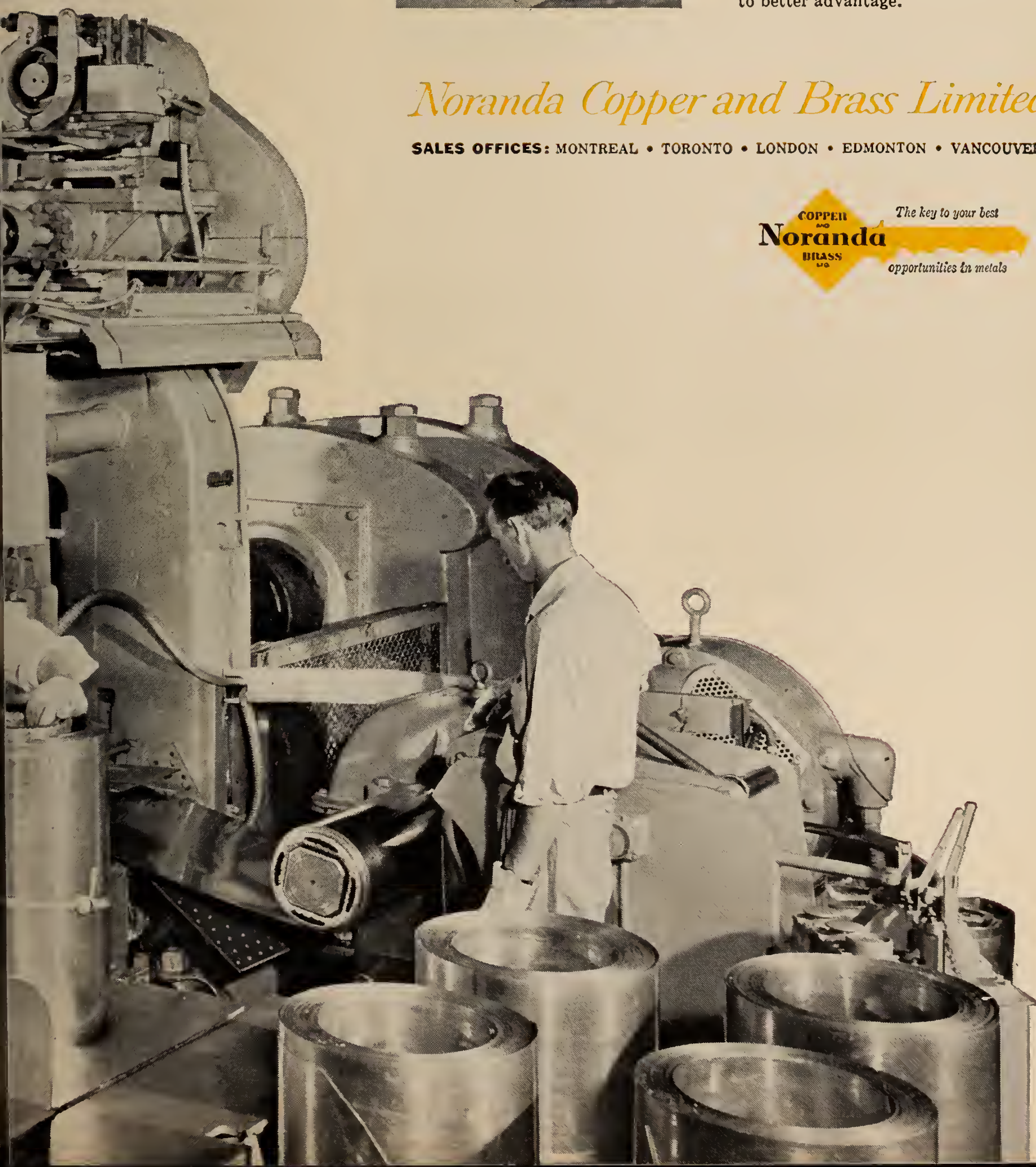

25 on progress of Confederation. Mr. Nadeau gave a brief history of engineering organizations in Canada. Mr. Nadeau said that with eleven professional societies spread across Canada, with their particular problems and viewpoints, it is difficult to arrive at a constitution agreeable to all. Unanimous agreement is necessary before confederation can be accomplished. However, Mr. Nadeau said definite progress is being made and in the course of time there will be confederation.

NIAGARA PENINSULA

E. C. Little, M.E.I.C., *Correspondent*

THE LADIES AUXILIARY of the Niagara Branch met for the first time at a tea on April 30 at the Niagara Falls Club. Some 65 ladies responded to the invitations that had been sent out.

Mrs. Lilian Robertson, Secretary of the Toronto office of the E.I.C. was guest of honour, and spoke on the aims of similar groups that had been formed in other districts.

AN EXECUTIVE DINNER was held on May 7 and the counting of the ballots resulted in the following members being elected for 1959-60; chairman D. O. D. Ramsdale; vice-chairman, E. D. Denham; past-chairman, D. A. Barnum; executive, R. T. Bailey; W. D. Tanner; H. S. Lundy; H. Jones; W. J. O'Reilly; W. J. Smith; A. Zahavich.

THE ANNUAL MEETING and Ladies Night was held on May 21.

Officers of the Women's Auxiliary are: president, Mrs. D. A. Barnum, vice-president, Mrs. E. C. Little, program convenor, Mrs. P. E. Buss, secretary, Mrs. D. O. D. Ramsdale, treasurer, Mrs. W. J. O'Reilly.

THE 6TH ANNUAL PROFESSIONAL ENGINEERS' BALL will be held at Prudhommes Garden Centre on the Queen Elizabeth Way at Vineland, on Friday, September 25, 1959.

Mart Kenney and his orchestra will provide the music. There will be a floor show consisting of two novelty acts. The plan is for the reception and cocktails at 6.00 p.m., dinner at 7.00 p.m., and dancing at 9.00 p.m.

R. T. Bailey is chairman of the dance committee; J. H. Travers (41 Rivercrest Drive, St. Catharines, Ont.) is publicity director.

OTTAWA

D. R. Grimes, JR.E.I.C., *Correspondent*

THE MUSKEG PROBLEM IN CANADA was the topic of a paper by I. C. MacFarlane of National Research Council at the luncheon meeting of May 7, 1959. Mr. MacFarlane is in the Soils Section of the Division of Building Research. There were about 60 members present.

Mr. MacFarlane defined muskeg as terrain made of living vegetation underlain by peat. Muskeg creates many engineering and economic problems. The petroleum industry has already spent $100 million dollars more than normal expenses for exploration in muskeg country.

Considerable research is being undertaken on this problem especially on the interpretation of muskeg from aerial photographs. The problem of transportation across muskeg is being attacked by the development of vehicles and by research into new and improved road construction methods.

E. B. EDDY COMPANY played host to the Ottawa Branch on May 14 when about 60 engineers toured the paper mill at Hull, Quebec. Three paper machines were in operation including the modern "Yankee" paper machine. This machine produces paper for serviettes and towelling in a continuous sheet 149 inches wide at a rate of 2,000 ft. per minute. The paper mill produces enough paper to encircle the globe, every two days, it is said.

AIR VICE MARSHAL C. L. ANNIS, O.B.E., CD., addressed a joint meeting of the E.I.C. and the Canadian Aeronautical Institute on May 21 with more than 100 engineers present. The topic he discussed was "Some Aspects of Canadian Aeronautical Development over a Half-Century".

Air Vice Marshal Annis emphasized the important role played by Mrs. Alexander Graham Bell in organizing and financing the Aerial Experiment Association in 1907. This association composed of Canadians and Americans added greatly to the interest taken in design and construction of aircraft in Canada and the U.S.

After some good years of initiative in design of aircraft adapted to Canada's geographical and climatic conditions, by 1923 the situation had changed. The producing aircraft industries in Canada now belonged to foreign parent firms. As a result, any research and development took place either in England or the United States. The Canadian industry was left to modify or make do with whatever aircraft the parent firms produced. During the second war, however, the financing of the design and development of aircraft shifted from private enterprise to government. The number of industries shrank and the development of original Canadian products began. Air Vice Marshal Annis concluded that great advances have been made in the original design and development of a particular aircraft by one Canadian firm. He said, however, that Canada's main effort has been the production and not the development of aircraft.

PETERBOROUGH

J. L. Olsen, JR.E.I.C., *Correspondent*

COL. SERGE STUKEN, M.E.I.C., Director, Engineering Services, spoke at a meeting on May 4, 1959 on the subject of "Canadian Arsenals".

He developed the progress of the Crown Company, now known as Canadian Arsenals Limited from the time in 1945 when a number of World War II munitions plants were grouped together.

The Company acts to supplement Canadian industrial capacity, but it is an association of six major Divisions. It has ten plants in Ontario and Quebec, and is capable of producing the ammunition, small arms, optical instruments and military radar which are required by the Canadian armed forces.

Colonel Stuken described the extent of the Company's operations, the precautions in handling high explosives; the mechanization of various operations concerned with the filling of projectiles and the assembling of ammunition. He also talked about the manufacture of the 7.68 mm. automatic rifle.

E.I.C. Annual Meeting

May 25-27, 1960,

WINNIPEG, MAN.

• BRANCH NEWS

PORT HOPE

D. A. Runciman, JR.E.I.C., *Correspondent*

J. W. McMillan, director of personnel development, Canada Packers Limited, Toronto, spoke on March 18 on the application of psychology to management placement. Mr. McMillan divides psychology to academic, social and industrial divisions. He illustrated the use and application of the industrial psychology with examples from his personnel experience. He discussed the use of E.I.M.F. (early identification of the management function) and the group appraisal system.

SAINT JOHN

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

Tuesday, May 19, a large group of members and ladies attended a dinner meeting at the Riverside Golf and Country Club. The meeting was arranged by the Professional Development Committee.

Harley K. Larsen, was the speaker. He showed two sound and technicolor movie films which were supplied by the Foundation Company of Canada. The film "Arctic Adventure" illustrated life in the Arctic and construction of the DEW Line. "Partners in Progress" showed the various large construction projects and services that the Company engineers have been recently associated with in Canada. Mr. Larsen also showed coloured slides illustrating his own experiences in the Arctic and in the Azores. Souvenirs of his travels were exhibited, such as mounted polar bear hides, Eskimo carvings and sealskin work.

ST. MAURICE VALLEY

Eric A. Love, JR.E.I.C., *Correspondent*

The patent system in general and in particular Canada's system were described by Gordon Asher of the Canadian Patent Office at a meeting on March 25 in Three Rivers.

The rules and regulations of patent application can be obtained for a nominal sum from Ottawa, the speaker said. His remarks on employer-employee relationship as regards inventions were of interest to all present. One of the most interesting statements was that "patents cannot be suppressed. If they are not worked compulsory licenses are given". There was a lively question period.

Industrial relations was the subject of a paper given on April 23 by J. J. Gagnon, director of personnel relations Aluminum Company of Canada.

For best results, Mr. Gagnon recommends that people be treated as individuals in their place of work. Skill and talent are required in industrial relations, beyond just common sense. People

want to know where they are going, and this is accomplished by good communication and information.

Personnel interest should be the business of top executives and interest should be stimulated in subordinates. Mr. Gagnon touched briefly on union problems including the internal problems facing some unions today.

TORONTO

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

Dr. L. E. Jones, of the University of Toronto was the speaker on April 9. His subject was "The Supercharger". He started with the simplest of pumping devices used in early times and traced the development through the years. Viewing a pump as a device for transforming energy from a convenient source to a fluid, Dr. Jones showed how each type of pump was capable of transmitting energy of specific characteristics such as high pressure, high velocity, or high flow volume.

In addition, he had a wide range of displays and demonstrations by which he illustrated both ancient and modern pumping devices.

Dr. Jones is an associate professor in the Department of Mechanical Engineering.

Professor D. A. MacRae, Professor of Astronomy, University of Toronto and David Dunlap Observatory, was the speaker on April 23.

Dr. MacRae outlined how radio astronomy developed from recent research performed on shortwave. In investigations of static interference, it was found that some interference was coming from outer space.

Classic optical methods of astronomy are limited by the transparency of space which is limited in certain directions. Radio astronomy is unlimited in range but does have problems of resolution and signal collection the same as optical astronomy.

The speaker described the construction and operation of the 85 foot antenna at Leydon, Holland, and the 250 foot antenna in Manchester, England, and he explained some of the specific contributions made by this new branch of astronomy.

A plant visit to Hinde and Dauch Paper Co. of Canada Ltd., attracted 150 members on May 7.

This plant, located in Toronto, produces boxboard for use in manufacture of containers, and has one of the fastest board machines on the continent. During the tour, the members were able to follow the process from the pulping of scrap paper to the finished board, as well as the testing facilities for both the board and the finished containers.

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations

CANADIAN COUNCIL

D. O. Turnbull Elected President of National Body

Donald Orton Turnbull, P.Eng., a native of Rothesay, N.B., has been elected president of the Canadian Council of Professional Engineers.

Since 1944, he has headed his own company, Turnbull and Scott Limited, in Saint John, N.B. which specializes in the design of marine structures and industrial buildings.

Donald Orton Turnbull, P.ENG.

Don Turnbull received his education at Rothesay Collegiate; Bishop Ridley School, St. Catharines, and Royal Military College from which he graduated in 1929 with an engineering degree.

In his early career he worked for Canadian Industries Ltd., and the Department of Marine, Hydrographic Service. Then he joined the Foundation Company of Canada as a job engineer on the reconstruction of the King Edward Pier in Montreal harbour. Later, he supervised construction of the breakwater at Liverpool, N.S., and the Alexandra Pier at Montreal harbour.

In 1939 he joined the Royal Canadian Air Force and became a navigator and navigation instructor. He was appointed the first chief ground instructor upon the formation of the RCAF's Central Navigation School, and later headed a technical development group at Air Force headquarters. He retired in 1944 with the rank of squadron leader, and formed his own consulting practice in Saint John.

He has served as chairman of the Saint John branch of the Engineering Institute of Canada and as councillor of the Institute, and he is also a member of the Consulting Engineers of Canada. He served as mayor of his hometown, Rothesay, and represented it on the County Council.

He is a director of Eastwood Industries Ltd., member of the advisory committee of Eastern Trust Company, and president of Turnbull Real Estate Company.

BRITISH COLUMBIA

The Continuing Obligations of the Engineering Graduate

Editorial reprinted from *The B.C. Professional Engineer,* April 1959.

In the next month, the Engineering Profession will welcome into its ranks more than 200 graduates in engineering from the University of British Columbia. Many of this group will leave the province, at least initially, to take up their first positions in engineering. Some will proceed with post-graduate education, either at the University of British Columbia or at other universities outside the province and the country. We hope that the great majority of these will return.

The profession owes a certain obligation to these young graduates. They have now completed the basic part of their academic training and for most of them, at least, there remains only to learn how to apply these principles, they have learned in theory, to actual practice. It is up to the senior members of the profession to assist them when assistance is needed, and to give them guidance. This assistance may take the form of constructive criticism but should always be available. Each junior engineer should be made to feel that there is some more senior engineer to whom he may turn for advice and guidance when necessary, and it is a responsibility that senior engineers in companies employing new graduates must accept.

Not only, however, is there an obligation upon the profession, but the graduate himself must accept certain responsibilities. His obligation is threefold. First of all, to himself; secondly, to the profession; and finally, to the community. These are not necessarily in order of importance.

The Graduate's Interests

It is incumbent upon a graduate in his own interests to ensure that the experience which he gains is such that his talents will be developed completely. He must realize at the outset that the experience that he gains in the first ten years after university will have a very important bearing upon his success in the approximately thirty years of professional life after that. He should weigh, then, any position he accepts in the light of the experience that he is going to gain in that position, should not allow any slight monetary gain to persuade him from accepting the position which will be most rewarding in experience. If he finds that, in the position which he accepts, he is not getting the experience which he expected to get, or, which is best suited to him, he would be doing himself and his employer a favour if he sought other employment which would give him the experience he wishes. He should look carefully at this, however, before changing positions and seek the guidance of a more senior engineer. He may find, for example, and it is usual in younger engineers, that he is developing but that he set his sights a little high. This is a good thing, and is to be encouraged, but he should not expect his employment to be just a training ground for him. It is important, too, that the graduate develop and maintain an interest in his work. He must always be learning and if he finds that he no longer needs to study to keep up with his work, then he had best take a good long look at himself and at his job, because he is not developing at the rate that he should.

Duties Towards Profession and Public

The graduate has an obligation, as well, to the profession. Upon graduation, he has spent approximately seventeen years in academic pursuits. He must now assure his elders that he is competent to practise, and he must do this by first of all learning by experience to put the principles he learned in university into actual practice, and then by presenting his credentials to his elders, so that he may be accepted by them into the profession. Regardless of whether he be in British Columbia or in any province in Canada, he should, as soon as possible after graduation, obtain registration as a professional engineer.

He should study the Code of Ethics of the profession and uphold that code, for therein are contained the rules of conduct by which he must live his professional life. He should be proud of his profession, and should serve as a good example to the public of the members of his profession.

Finally, the engineer has an obligation to the community. This obligation is last only chronologically, and not in importance. The graduate engineer must, in his early years after graduation, expend his major effort in getting himself established and in developing his own professional life. Once he has been established, however, he must lend his talents to the community at large and take an active interest in community affairs, such as education, civic affairs and welfare activities. He has received the benefit of the higher educational system in our country, and he must be prepared to pay back some of the dividends.

News of Other Societies

Steel Fabricators Meet

The largest meeting of the Canadian Institute of Steel Construction in the history of C.I.S.C. was held on May 22 and 23, 1959, at the Seigniory Club, Montebello, Que., with over 230 people attending. Mills were well represented, both Canadian and American, in addition to all Canadian steel fabricators.

These officers were elected at the meeting: president, W. A. Hepburn, vice-president, John T. Hepburn Ltd., Toronto; vice presidents, G. E. Ellsworth, president, Toronto Iron Works Limited, Toronto; E. A. Ford, vice-president, marketing division, Dominion Bridge Co. Ltd., Montreal; R. Raitblat, president, Standard Iron and Steel Company of Canada Ltd., Montreal; honorary treasurer, F. R. Murray, manager, Truscon Steel Company of Canada Ltd., Montreal.

General manager of C.I.S.C. is D. C. Beam, M.E.I.C. There are three regional engineers.

Committees of the C.I.S.C. reported to the annual meeting. President W. A. Hepburn reviewed the past year. Its 49 fabricator-members employ 18,000 Canadians and have total assets in excess of $350 million. He expects the Institute's activity in the next 12 months to surpass that of the last year. This, viewed with the brighter business forecast, reflects the vitality of the industry as a whole.

Some of the subjects dealt with in papers on the program were: Public Relations for the Steel Industry, by Wallace Harper, Assistant Executive Vice President, American Institute of Steel Construction, Inc., and

Competing materials — a Challenge to Management, by Robert E. Willmot, Sales Manager, Structural Shapes, Bethlehem Steel Co.

Chemical Institute Conference

The Chemical Institute of Canada held the 42nd annual conference at Halifax, N.S., May 25-27, 1959.

In the technical program speakers reported on recent advances in chemistry and chemical engineering. Some of the topics were: manufacture of basic petrochemicals; advances in cancer research and diagnosis of virus diseases with the aid of new techniques of tissue culture; "science fairs" as a means of encouraging the work of high school students in science; methods of codfish preservation; the program of outdoor testing sites to study weathering of building materials; the uses and handling of fluorine; storage of strontium-90; new work on metabolism using radioactive carbohydrates; dietary supplements which prevent formation of kidney stones in cattle; use of low grade Canadian ores to replace imported ores to make ferro alloys for steel manufacture; advances in cancer research due to new techniques of tissue culture; crude oil as raw material for petrochemicals.

The C.I.C. annual awards to members of the chemical industry were announced and presented (where possible) at the annual meeting.

Fellowship in the C.I.C.: awarded to twenty nine chemists and chemical engineers, from twelve cities. They were: S. D. Cavers, G.G.S. Dutton, R. Stewart, H. G. Khorana, Vancouver; S. A. Brown, E. J. Wiggins, Saskatoon; S. G. Davis, Edmonton; M. Cohen, W. H. Cook, R. J. Cvetanovic, O. E. Edwards, D. S. Montgomery, Ottawa; R. M. Butler, C. T. Steele, J. L. Tiedje, G. A. Olah, W. H. Arison, Walkerville; W. E. Grummitt, Chalk River; S. E. Jack, J. K. N. Jones, Kingston; R. H. Pearce, London; A. L. Tosoni, Toronto; H. Favre, D. A. I. Goring, A. Sehon, A. Taurins, Montreal; A. Cholette, I. Cameron, Quebec.

C.I.C. Medal: awarded annually for outstanding contributions to chemistry, this year to Richard H. Manske, director of research, Research Laboratories, Dominion Rubber Co. Limited, Guelph, Ont.

Ogilvie Fellowship: — first award made to Robert R. Matsuo of Winnipeg, for research in cereal chemistry.

Montreal Medal: — presented in recognition of significant leadership to Thorbergur Thorvaldson of Saskatoon, former dean of the College of Graduate Studies, University of Saskatchewan.

Officers Elected

E. Gordon Young, Director, Atlantic Regional Laboratory, National Research Council, Halifax, N.S., was elected president of the Chemical Institute for 1959-1960. William N. Hall, president, Dominion Tar and Chemical Co., Limited, Montreal was elected vice-president. Newly elected councillors taking office at this meeting, to complete the slate of 36 councillors, were: A. C. Cuthbertson, Sackville; B. A. Fairbairn, Drummondville; W. M. Campbell, Chalk River; B. A. B. Clark, Toronto; C. Sivertz, London; H. V. Kidd, Brandon; B. H. Levelton, Vancouver; M. R. Feely, Toronto; Paul E. Gishler, Edmonton; K. J. McCallum, Saskatoon; C. E. Coke, Montreal.

Calendar

Institute of Power Engineers. 1959 Canada Power Show, October 1-3, Toronto, Ont.

Mexican Society of Soil Mechanics. First Panamerican Conference on Soil Mechanics and Foundation Engineering, University of Mexico, Mexico City, September 7-12, 1959.

Societe Francaise de Metallurgie (25, rue de Clichy, Paris (9e)). Journées Métallurgiques d'Automne, Paris, October 19-24, 1959. Gas in Metals is the theme.

British Interplanetary Society. Tenth congress of the International Astronautical Federation, Church House, Westminster, London, August 31 to September 5, 1959.

International Council of Societies of Industrial Designs. Congress, Stockholm, September 16-18, 1959.

Associate Committee on Soil and Snow Mechanics of the National Research Council, Canada. Thirteenth Canadian Soil Mechanics Conference, at Nova Scotia Technical College, September 10-11, 1959. Information from E. Penner, Division of Building Research, N.R.C., Ottawa 2, Ont.

Canadian Good Roads Association. Annual Convention, September 22-26, 1959, Vancouver, B.C.

Massachusetts Institute of Technology. Two-week summer program on "The Shear Strength of Soils"; August 31 to September 11, 1959.

Community Planning Association of Canada. National Planning Conference, September 13-16, 1959, Sheraton Mount Royal Hotel, Montreal, Que.

American Meteorological Society. Conference on Stratospheric Meteorology, Minneapolis, Minn., August 31, September 3, 1959; Conference on Weather Modification by Artificial Means, August 27-29, 1959, Denver, Colorado.

McGill University. Seminar on Arctic and Stratospheric, Meteorology, July 27 to August 7, 1959, Stanstead College, Stanstead, Que., Enquiries to Prof. F. K. Hare, McGill University, Montreal.

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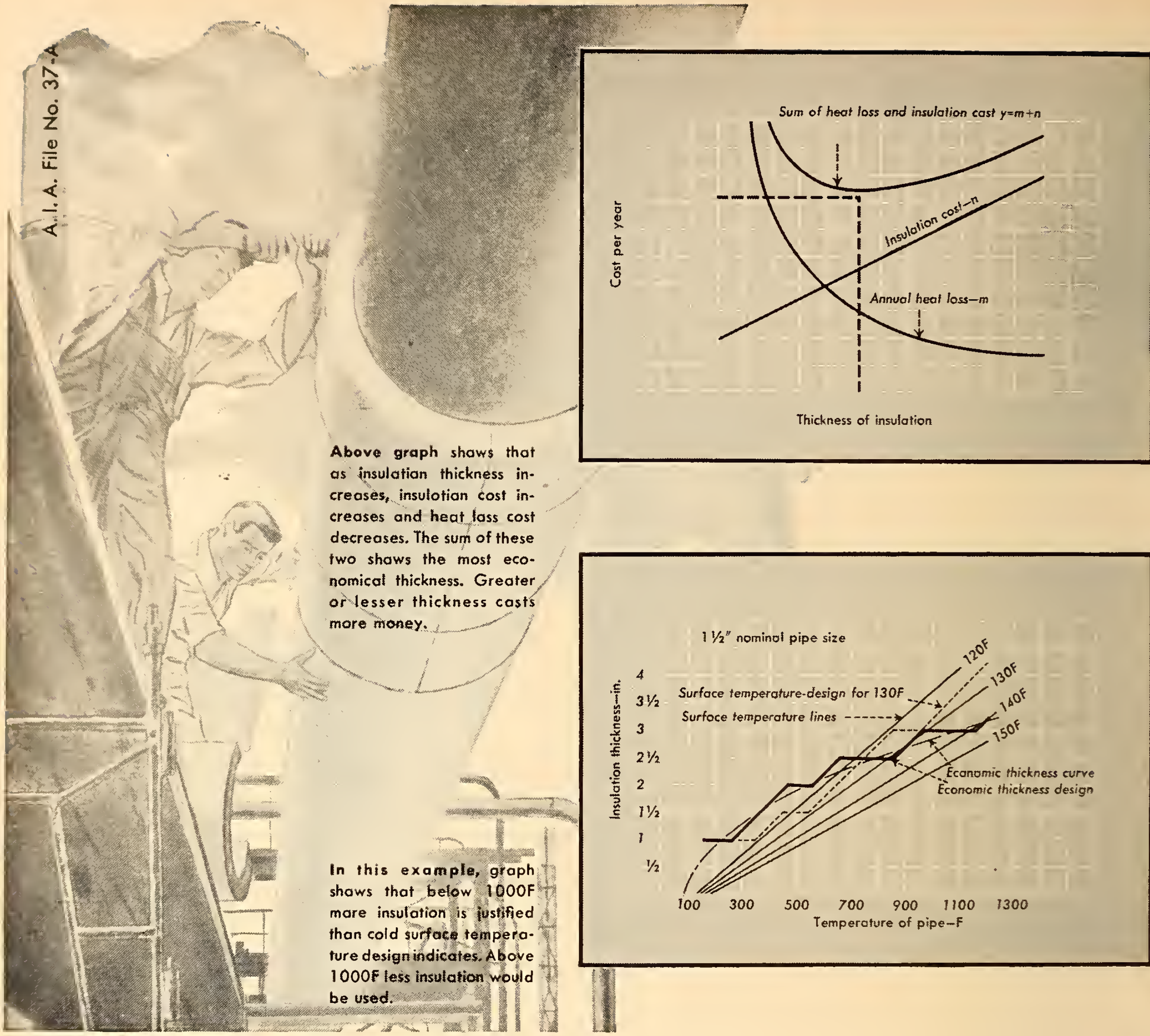

Above graph shows that as insulation thickness increases, insulation cost increases and heat loss cost decreases. The sum of these two shows the most economical thickness. Greater or lesser thickness costs more money.

In this example, graph shows that below 1000F more insulation is justified than cold surface temperature design indicates. Above 1000F less insulation would be used.

"COLD SURFACE" CRITERION WASTES MONEY!

How J-M engineers determine economic insulation thickness

to give you more for your insulation dollar

Over-all cost of the operation should always be the determining factor in selecting insulation thickness. Yet, millions of dollars have been wasted because of rigid adherence to the cold surface temperature method. When Johns-Manville insulation is applied, J-M engineers carefully determine which thickness will provide the greatest operational savings. And this "economic thickness" is usually more (or less) than the cold surface method indicates.

Here's how it works. The annual cost of the heat loss through the insulation is plotted for various thicknesses. Also plotted is the annual cost of insulation. A third curve is then drawn as the sum of heat loss and insulation cost. The economical thickness is found where this third curve reaches its lowest point.

To arrive at the above figures in a given instance requires the following: 1. Cost of heat production per million Btu; 2. Rate of heat loss through insulation in Btu per unit area per hr; 3. Annual hours of operation; 4. Applied cost of insulation per unit area; 5. Rate of amortization and required return on the insulation investment cost. Items 2 and 4 are available from the insulation manufacturer; others are normally supplied by the plant engineer.

For more complete information, call or write Dept. IA, Canadian Johns-Manville Co. Ltd., Port Credit, Ontario. Ask for reprint of technical article "Select Economic Insulation Thickness."

I-4034

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BOOK 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.

***EXPANSION MACHINE FOR LOW TEMPERATURE PROCESSES**

Following a brief history of the development of engines for refrigerative purposes, there is a discussion on low temperature refrigeration systems; engines and turbines for gas liquefaction, and expansion engines in low temperature systems. These systems are considered in relation to their application to many low temperature processes. (S. C. Collins and R. L. Cannaday. Toronto, Oxford, 1958. 112p., $2.00.)

***THE CONTEMPORARY CURTAIN WALL: ITS DESIGN FABRICATION, AND ERECTION**

A manual covering various aspects of curtain wall systems. It analyzes and evaluates the walls, their functions and malfunctions, component parts, materials and installations. Tables and lists give known data on insulating efficiency, fire resistance, dimensional stability, and similar factors. Pitfalls are pointed out, known solutions outlined, and accepted good practice specified. Many drawings are given to show construction details, and photographs are included to illustrate contemporary examples of the curtain wall. (W. D. Hunt. New York, Dodge, 1958. 462p., $12.75.)

***CONSTRUCTION ACCOUNTING AND FINANCIAL MANAGEMENT**

Proper accounting and management procedures are related to the basic operational patterns of the construction firm. Topics discussed are prejob procedures, purchasing policies, change orders, vouchering, control of receipts and disbursements, classification of accounts, financial statements and reports, auditing, insurance, and business machines as well as other aspects. Practical reasons are given to indicate why procedures that are standard in other businesses are either not used or are sharply modified. (W. E. Coombs. New York, Dodge, 1958. 490p., $12.85.)

***THE ANALYSIS OF GRID FRAMEWORKS AND RELATED STRUCTURES**

Presents a practical method of calculating the distribution of bending moments, deflections, etc., in a variety of structures such as bridge decks, interconnected beams, cantilevers, and arches. The first part deals with commonly occurring structures which can be analyzed by means of plotted coefficients, while the second is an analytical section containing the derivation of these coefficients and the application of the method to more complicated problems which cannot be solved in general terms. A concluding section describes experimental work on model and large scale structures which provide confirmation of the accuracy of the methods described. (A. W. Hendry and L. G. Jaeger. London, Chatto and Windus, 1958. 308p., 50/-.)

***DYNAMICS AND NONLINEAR MECHANICS**

The first part of the book surveys modern analytical progress in the treatment of problems relating to the dynamics of rigid bodies and celestial mechanics. The second part outlines the current knowledge of the analysis of non-linear oscillating systems, and discusses general methods, methods of approximations, oscillations in nearly linear systems, and relaxation oscillations. Volume II in "Surveys in Applied Mathematics". (E. Leimanis and N. Minorsky. New York, Wiley, 1958. 206p., $7.75.)

***MATHEMATICAL ASPECTS OF SUBSONIC AND TRANSONIC GAS DYNAMICS**

The author is concerned with a limited part of the theory of compressible fluid flow: two-dimensional steady potential flows. Mathematical methods are emphasized rather than the physical problems themselves, and the "applications" of fluid dynamics as a source of mathematical concepts are stressed. Particular attention is paid to existence and uniqueness questions for subsonic and transonic flow problems. Volume III in "Surveys in Applied Mathematics". (L. Bers. New York, Wiley, 1958. 164p., $7.75.)

***SOME ASPECTS OF ANALYSIS AND PROBABILITY**

Presents four aspects of the subject. The first is functional analysis and includes topological linear spaces, Banach algebras and group representations. This is followed by a survey of combinational analysis which deals with methods of enumeration, theorems on choice, and the existence and construction of designs. The concluding sections cover abstract harmonic analysis and recent advances in probability theory, including sums of independent random variables, general random elements and functionals of random functions. Volume IV in "Surveys in Applied Mathematics". (I. Kaplansky and others. New York, Wiley, 1958. 243p., $9.00.)

***NUMERICAL ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS**

The first portion of the book deals with recent developments in numerical analysis, which is viewed by the author as a means of devising and evaluating numerical techniques for computers. Emphasis is placed on Russian contributions to this field. The second part studies the work which has been done in linear partial differential equations since 1953. Methods are given which are applicable to wide classes of equations, and in most cases results are stated in the form of definite theorems for the sake of easy reference. Volume V in "Surveys in Applied Mathematics". (G. E. Forsythe and P. C. Rosenbloom. New York, Wiley, 1958. 204p., $7.50.)

LE BRUIT DE FOND

The first of a series of electronics books to be issued by this publisher, this volume deals with background and random noises. The authors commence with basic experiments in the field, the work of Schottky and Nyquist, and basic laws.

Other topics covered include sound transmission in passive and active networks; noise index; photoelectric cells, and amplification by secondary emission, semi-conductor noise; mathematical representation; information theory and the calculation of probabilities. References for additional reading add to the value of this very useful volume. (P. Grivet and A. Blaquiere. Paris, Masson, 1958. 495p., 6,500 fr.)

CALCULATEURS ANALOGIQUES REPETITIFS

Concerned with the problems of repetitive differential analysis, the first part of the book discusses theory, the principles of solving mathematical problems with differential equations by the analog method. The second section is concerned with the elements of the calculation, and complete installations. Particular attention is paid to nonlinear equations. The last section discusses applications of this type of computer in the solution of ordinary differential equations and integral equations, and high-speed computing techniques. There is a useful bibliography. (Rajko Tomovic. Paris, Masson, 1958. 186p., 3,000 fr.)

• LIBRARY NOTES

PROBLEMS DE GEOLOGIE SOUS-MARINE

As the author points out, knowledge of the floor of the ocean is important for laying of cables and pipe-lines, development of harbours, disposal of radio-active wastes, etc. The first section of the book considers the geology of the "Précontinent", the area of the Continental Shelf, its geology, its boundaries, and sedimentary deposits. The second section covers the area more immediate to the shore, cliffs, coastlines, estuaries, and sandy beaches. (Jacques Bourcart. Paris, Masson, 1958. 123p., 980 fr.)

°ETUDE D'UNE PLAQUE RECTANGULAIRE RAIDIE PAR DEUX POUTRES DE RIVE

A theoretical and experimental study of the resistance to stress of thin rectangular plates reinforced by parallel supporting beams. The problem is first studied mathematically and a formula for determining the deflection and bending of plates under vertical loads is obtained. The second part describes an experimental study on the basis of this formula, utilizing a steel model. The results of the theoretical and experimental studies are then compared. Number 7 in the series Cahiers de la Recherche Théorique et Expérimentale sur les Matériaux et les Structures. (Z. Hashin. Paris, Eyrolles, 1958. 141p., (2,795 fr.)

ROCKET PROPELLANTS

The author is manager of the Special Projects Section of the Southwest Research Institute's Department of Chemistry, and in this volume he presents the history of rocket fuel development, and basic information of today's rocket propellants. It includes information on the composition, manufacturing methods, and performance details of solid- and liquid-propellants used in rockets, and on propellant burning, ignition and igniters, and the rockets using each kind of fuel. There are also chapters on safety in manufacturing, quality control, and the future of propellants. Bibliographies are included in each chapter. (F. A. Warren. New York, Reinhold, 1958. 218p., $6.50.)

CHEMICAL ENGINEERING PRACTICE, VOLUMES 5 AND 6

These two volumes continue the discussion of chemical engineering operations and processes involving fluid systems begun in volume 4.

Each chapter is written by an expert. Volume 5 deals with the transportation of gases and liquids; high pressure vessels; vacuum production; liquid-liquid systems; and distillation. Volume 6 covers liquid-gas systems; fluidization and fluidized beds; multicomponent gas systems; liquid-solid systems, leaching, colloids, filtration, centrifuging; solid-vapour systems, sublimation and vacuum freeze drying.

The series will be completed in twelve volumes. (Ed. by H. W. Cremer. Toronto, Butterworth, 1958. v.5, 695p. v.6, 600p. ea. $17.50.)

TEN STEPS INTO SPACE

A series of semi-technical lectures on astronautics sponsored by the Franklin Institute in 1958. The lectures covered the history of space travel; the principles of rockets and rocket fuels; satellite instrumentation; satellite orbits; the Explorer; the atmospheres of Venus and Mars; space medicine; space travel. The authors are all experts in their respective fields. (Philadelphia, Franklin Institute, 1958. 202p., $4.00.)

THE DETERMINATION OF NITROGEN IN STEEL

Another of the special reports issued by the Iron and Steel Institute, this report is concerned with the two methods in use for determining the nitrogen content of steel. The first section deals with chemical determination, and describes the methods employed, results obtained on the steels examined, a discussion of the results, and a proposed standard method.

The vacuum-fusion method is considered in part two, the factors affecting the accuracy of the method, and a

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discussion of the results, and the two methods are compared. There is a special section dealing with the chemical determination of nitrogen in ferrochromium. Many of the results of the tests are presented in tabular form. (London, Iron and Steel Institute, 1958. 146p., 37/6.)

*PILES, CULEES ET CINTRES DES PONTS

This study of the piers, abutments, and arches of bridges begins with a short essay on the aesthetics of bridges. It then discusses piers and abutments and their resistance to various kinds of stress. A section on their erosion follows based on studies of the ruins of bridges. The main types of arches are then decribed and the book concludes with a study of the materials used in bridge construction including wood, concrete, and metals. (J. R. Robinson. Paris, Dunod, 1958. 316p., 3,600 fr.)

SURVEY OF MINES, 1959

This 408-page basic reference book reports that Canadian mining is preparing for greater mineral demands of expanding industry throughout the world.

It provides details on all active mining companies in Canada as well as thousands of others, and includes 22 pages of up-to-date maps of important mineral areas, an eight-year price range of stocks, mineral production tables going back to 1858.

Beside data on Canadian mines, the book also includes stock commission rates, lists of milling plants and metal prices. (Financial Post, Toronto, 1959. 368p., $4.00.)

*ELASTICITY AND PLASTICITY

A study of the mathematical theories of elasticity and plasticity, stressing modern trends in analysis. Emphasis is placed on the contributions made by Russian authors to this field, and extensive bibliographies are given. Volume I in "Surveys and Applied Mathematics". (J. N. Goodier and P. G. Hodge, Jr. New York, Wiley, 1958. 152p., $6.25.)

ENGINEERING LAW, 5TH ED.

Many textual revisions have been made in this edition, and citations of recent judgements added. The chapter on "Professional Engineering" has been moved to the beginning of the book, and chapters have been added on legal problems in mines, oil and gas wells, and pipe lines, public utilities and public health. The aim of the book is to present a simple treatment of the legal aspects of engineering undertakings and responsibilities. Most of the judgements cited are based on common law, and only occasional reference is made to the Quebec Civil Code. (R. E. Laidlaw, C. R. Young and A. R. Dick. Toronto, University Press, 1958. 461p., $6.95.)

KEMPE'S ENGINEERS YEAR BOOK

This sixty-fourth edition has, as usual, been thoroughly revised, and the sections on flow metering and mechanical testing, refrigeration, and paints rewritten. Additional material has been added to many of the seventy-nine chapters, including that on Mechanics which now includes the fundamental formulae dealing with motion of missiles and satellites, and escape velocity. Practically every branch of engineering is covered. (Ed. by C. E. Prockter. London, Morgan Bros., 1959. 2 vols. 85/-.)

BETON PRECONTRAINT. T.2 CONSTRUCTIONS HYPERSTATIQUES

The first volume of Guyon's well-known work on prestressed concrete was concerned primarily with general problems. This second and final volume deals primarily with beams and beam assembly, and certain types of slabs.

In the first part of the book the applicable elastic methods of design are discussed in relation to the calculation of beams, arcs, etc. The second part is a critical examination of these elastic methods, and their results compared with those obtained by other methods. The final chapter presents a method of calculation of breaking point. (Y. Guyon. Paris, Eyrolles, 1958. 818p., 9684 fr.)

UNIVERSITY MATHEMATICS, 2ND ED.

Intended for a first-year course in pure mathematics, this volume covers all branches with the exception of projective geometry. The material is taken from the syllabus of the London University science degree. Many worked examples are included, as are the answers to the problems found at the end of each chapter. (Joseph Blakey. London, Blackie, 1958. 582p., 35/-.)

*NOMOGRAPHY

Discusses the methods of constructing nomograms along with a thorough presentation of the underlying theory. Except for two chapters, only a knowledge of analytical geometry is required. Topics covered include determinants, projective transformations, matrix multiplication, more than three variables, empirical nomography, Kellogg's method, and nonprojective transformations. (L. I. Epstein. New York, Interscience, 1958. 134p., $4.50.)

THE WORLD ALMANAC, 1959

The amount of information in the Almanac is, as usual, amazing. The events of 1958, both U.S. and worldwide, are reported. The usual information is included on sporting events, chronology, population and geographical statistics, etc. No library should be without it. (Ed. by H. Hansen. New York, World-Telegram, 1959. 896p., $1.50.)

*FIELD INSPECTION OF BUILDING CONSTRUCTION

Following a discussion of the job of the inspector, several chapters cover

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various phases of construction: the preliminary, foundation, structural framing, intermediate, and finishing stages. Because of the complex problems of inspecting concrete work, a special chapter is devoted to these materials. Responsibilities are defined and explained for such matters as quality of materials, quality of workmanship, coordination of work by different trades, schedules, storage of materials, provision of utilities and services, safeguarding of work in place, and safety precautions. (T. H. McKaig. New York, Dodge, 1958. 352p., $9.35.)

°HYDROLOGY FOR ENGINEERS

Emphasizes practical, well-tested methods for the application of hydrology in engineering. Techniques are stressed which utilize correlation methods and eliminate judgment to the maximum possible extent. Topics covered are weather, precipitation, streamflow, evaporation and transpiration, groundwater, runoff, streamflow routing, frequency and duration studies, sedimentation, and application of hydrologic techniques. (R. K. Linsley, Jr. and others. Toronto, McGraw-Hill, 1958. 340p. $9.20.)

°NUCLEAR ENGINEERING HANDBOOK

A comprehensive survey of nuclear theory and of nuclear engineering principles and techniques. Aspects covered include nuclear data, nuclear physics, experimental techniques, reactor physics, radiation and radiological protection, control of reactors, fluid and heat flow, reactor materials, chemistry and chemical engineering, nuclear power plant selection, mechanical design and operation of reactors, and isotopes. The material is presented on a practical level for engineers interested in the industrial uses of nuclear energy. (Ed. bv H. Etherington. Toronto, McGraw-Hill, 1958. Various paging. $25.00.)

°MAN THE MAKER

A history of technology and engineering in which power resources, transportation, communication, metallurgy, textiles, glass, chemical technology and some aspects of civil engineering are covered. The inventions of prehistory, of the Ancient East, the Greeks and Romans, the Arabs, the Middle Ages, the sixteenth and seventeenth centuries, the Industrial Revolution, and the modern era are also discussed, as are the relationships of the inventors to each period. (R. J. Forbes. New York, Abelard-Schuman, 1958. 365p., $5.00.)

°ELECTROMECHANICAL ENERGY CONVERSION

The fundamentals of analytical dynamics are used to establish a base for understanding the interactions in an electro-mechanical system. The first part of the book stresses dynamics, interconnected systems, and feedback control theory, while the second part gives detailed and specialized treatments of transducers, commutator machines, induction machines, and synchronous machines. To illustrate the unity that exists in the analysis of machines, a two-phase model of an electric machine is developed and its equation of motion derived and used in all the machine analyses of later chapters. (D. C. White and H. H. Woodson. New York, Wiley, 1959. 646p., $12.50.)

°THE POTENTIAL THEORY OF UNSTEADY SUPERSONIC FLOW

A systematic survey of aerodynamic forces which result from unsteady motion of the structural components of high speed aircraft. Beginning with a discussion of the basic equations of potential flow in their exact and approximate forms, the author develops the available methods of solution, and applies them to typical supersonic wing, slender body, and wing-body combinations. Illustrative calculations are given for harmonic motions such as occur in dynamic stability and flutter problems, and also for transient motions as in gust entry. (J. W. Miles. Toronto, Macmillan, 1959. 220p. $7.65.)

°ANALYSES OF INDUSTRIAL OPERATIONS

Case studies that show the actual application of quantitative methods to the analysis of industrial operating problems. The studies included are arranged according to method of analysis, and sections are given dealing with applications of linear programming, other programming applications, waiting line applications, total cost and value models, and applications of incremental analysis. The studies selected are intended to illustrate the simplifications, assumptions, method modifications, data needed, action, and results associated with operations analyses. (Ed. by E. H. Bowman and R. B. Fetter. Homewood, Ill., Irwin, 1959. 485p., $9.55.)

°SEMICONDUCTOR ABSTRACTS—VOLUME IV—1956 ISSUE

This volume covering the literature of 1956 and some of 1955, has been expanded by the inclusion of abstracts of unpublished papers presented at meetings of the American Physical Society and the Electrochemical Society. Abstracts are arranged by subject area and cover germanium; silicon; carbon, selenium, and other elemental semiconductors; intermetallics; sulfides, selenides, and tellurides; oxides; halides; organics; theory. An author and subject index is provided. (Compiled by Battelle Memorial Institute. New York, Wiley, 1959. 456p., $12.00.)

(continued on Page 153)

Employment
Bulletin
No. 59-7

EMPLOYMENT SERVICE

SITUATIONS WANTED

MECHANICAL ENGINEER, Jr.E.I.C., B.E., 1951, age 37, married, veteran. Seeks position requiring initiative, organizational ability, dependability, and with opportunity for advancement. Experience includes planning, design, layout, estimating, development, production supervision. Presently employed in pulp and paper industry but will consider other. Located Atlantic Province. File No. 4025-W.

PROFESSIONAL MANAGER, M.E.I.C., P.Eng. (Ont.). B.A.Sc. (Mechanical), M.B.A., Canadian born, age 38. Presently employed senior management level. Desire general management or senior industrial sales position. Presently located Central Canada but willing to locate anywhere. Your confidence respected and full resume supplied. File No. 5549-W.

MECHANICAL ENGINEER, M.E.I.C., age 34, married. Varied experience including project, maintenance and mechanical design engineering in several fields. Seeks change to interesting position where past experience could be best utilized. Would prefer to locate in or near Montreal or Vancouver, or in Ontario, but other locations considered. A detailed resume of experience and technical qualifications etc., is available upon request. Located Prairie Province. File No. 4659-W.

CIVIL ENGINEER, N.S.T.C., 1951, Jr.E.I.C., P.Eng. Que., married, 37 years, bilingual. Three years' experience in general contracting, one year in smelter construction, four years marine and industrial design and construction and eight years' pre-graduate experience in hydro-electric and heavy industrial construction. Desires responsible position with consulting engineering firm or general contractor as resident or project engineer. Available upon reasonable notice to present employer. Presently located, Central Canada. File No. 5035-W.

PROJECT ENGINEER, Jr.E.I.C., P.Eng., (Ont.), B.A.Sc., (Mech.Eng.), U.B.C., 1951, age 37, married, two children, Canadian. Presently employed, Latin America, returning Canada August, 1959. Eight years petroleum refinery, petrochemical plant experience, including equipment inspection; piping, vessel, structural design involving programming of selected problems for a high speed digital computer; development of major refinery expansion projects. Seeks position with responsibility, good prospects for advancement. Located Scotland. File No. 5126-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. 5456-W.

EXECUTIVE CIVIL ENGINEER, M.E.I.C., A.M.I.C.E., M.A. Cambridge, English born, Canadian citizen, 36, married, one child. 15 years' heavy construction, engineering experience in Canada, U.K., Africa, United States, Middle East. Presently in top construction management position. Particular experience in water, hydro dams, road work. Desires association with company engaged or contemplating construction or engineering, West Indies, Caribbean, Central, South America, for assignment on long term basis. Ambitious energetic, seeks position with executive ability requirement, corresponding compensation. Resume, references on request. Located Central Canada. File No. 5521-W.

MECHANICAL AND MARINE ENGINEER. P.Eng., M.E.I.C., M.I.E.S., M.I.Mar.E., experience: organization, administration, University Courses both subjects. Many years Naval, Merchant ships experience, including Salvage operations. Certified First Class Foreign-Going, Steam, Diesel. Good knowledge contractual work, supervision tests, trials, repairs, new construction, workshops. Actual technical experience most types boilers, turbines, turbo-electric, diesel, diesel-electric, diesel hydraulic. Resume of experience and education sent on request. Located Central Canada. File No. 5534-W.

ENGINEERING PHYSICIST, Jr.E.I.C., P.Eng., (Alta.), U. of T. 1956 Geophysics. Aged 26, single, present location Prairie Province. Three years' experience in seismic exploration business. Also some experience in other geophysical methods. Mathematically inclined and desires challenging position in research or the field of applied mathematics. File No. 5552-W.

B.Sc. IN MECHANICAL AND AGRICULTURAL Engineering, Jr.E.I.C., P.Eng. (Ont.), age 33, married. Experience in agricultural implement design; process air systems including compressor design, ducting, and instrumentation; equipment selection, plant layout, optical alignment, and engineering specifications; supervision of draughting, manufacturing, and installation. Desires position in mechanical design, industrial engineering, or consulting. Locate anywhere, Toronto area preferred. Present location Central Canada. Available on short notice. File No. 5554-W.

CIVIL ENGINEER, Jr.E.I.C., B.A., B.A.Sc. (Laval), Prof. Eng. Que., 1955, bilingual, married, varied engineering and some administrative experience, seeks employment with industry or consulting firm. Present location: Eastern Quebec. Willing to relocate anywhere in Quebec. File No. 5572-W.

MECHANICAL ENGINEER, Jr.E.I.C., P.Eng. (Ont.), McGill, 1951, age 34, veteran, single. Experience with large electrical manufacturer. Four years as manufacturing engineer. At present in design field. Business Administration studies. Seeking challenging position. Location preference Toronto or Montreal. File No. 5576-W.

GRADUATE CIVIL ENGINEER, S.E.I.C., B.Eng., age 27. Experience: 1 year lecturing — demonstrating, civil engineering courses. 1 year structural steel design and reinforced concrete design. 1 year structural steel and reinforced concrete construction. Located — Central Canada. File No. 5577-W.

CHEMICAL ENGINEER, Jr.E.I.C., P.Eng. (Ont.), B.Sc., Queen's 1955, age 27. Three years' supervisory experience in nuclear reactor operations. Desires development work. Returning to Canada at the end of August, after a year in the U.K. Detailed resume on request. File No. 5581-W.

GRADUATE MECHANICAL ENGINEER, Jr.E.I.C., age 35. Specialized in ship power plants, speaks French and Italian fluently, good knowledge of English and German. Seeks permanent position in Canada. Presently working as senior design engineer in a leading Swiss manufacturer of boilers and industrial, domestic furnaces. File No. 5583-W.

ELECTRICAL ENGINEER, Jr.E.I.C., P.Eng., N.S.T.C., 1951. Single, age 39. Applicable experience (5) years' service and maintenance on power apparatus, electronic controls. Post graduate automatic control studies at McGill University. Naval artificer during war. Would desire appropriate position, temporary or permanent in Canada. Present location Central Canada. File No. 5587-W.

ELECTRICAL ENGINEER, P.Eng. (Quebec) with sound background in communications, automatic instrumentation and data processing seeks to join consulting firm engaged in industrial, power development, electrical or communications work. Particulars and references on request. File No. 5589-W.

MECHANICAL ENGINEER, S.E.I.C., graduate University of Saskatchewan 1957, age 24, married, one child. Experience consists of 2 years with the armed forces as a construction engineering officer. Work includes supervision of all engineering maintenance, operation, new construction, alteration of buildings, facilities and services. Desires position in heating and ventilation field or administrative field where an engineering background would be an asset. Present location Maritime Province. File No. 5590-W.

CHEMICAL ENGINEER, Jr.E.I.C., P.Eng. (Ont.), McGill 1955, age 26, married, Canadian. Presently employed in Latin America, returning to Canada August 1959.

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.

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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.

CANADIAN DEVELOPMENTS *(Continued from page 100)*

Refrigerants in Construction

The use of refrigerants to freeze a subsurface area and thus avoid danger of subsidence was adopted in a Canadian National Railway project in Montreal. The job consisted in removal of a 140 ft. length of centre supporting wall and two roof arches inside the central station end of the Mount Royal rail tunnel, erection of a single reinforced concrete arch in their place, and rearrangement of some 1,800 feet of track.

To avoid danger to foundations of adjacent large buildings, soil stabilization by mechanical refrigeration offered technical advantages. In an area measuring 80 ft by 50 ft., comprising some 80,000 cu. ft. of unstable soil below street level, the Foundation Company of Canada, acting as contractor to the C.N.R. installed an intricate system of inter-connected pipes. The system carried ten tons of refrigerated methanol solution, freezing the ground to a depth of 18 to 20 feet. Before excavation and during work on the tunnel, the methanol flowing through the pipes was cooled by Freon 12 fluorinated hydro-carbons to a temperature of 10 degrees below zero F.

Moncton Classification Yard

Canadian National Railways has called for tenders for construction of a diesel shop at the Moncton hump yard. Measuring 263 feet by 340 feet, the diesel repair and service installation will be patterned on similar shops in Montreal and Edmonton.

The $15 million electronic classification shop yard in Moncton will be the eastern installation in the C.N.R. chain of new freight marshalling yards.

Steel Pile Cell Dock

Uncommon use of steel sheet pile cell dock construction in the Great Lakes has succeeded, it is reported.

An L-shaped dock constructed by Dravo of Canada Limited, Toronto, at Millhaven, Ont., for Liquefuels Limited, has three 35-foot diameter mooring cells, connected by structural steel walkways. A 450-foot berm allows access from the shore. The walkway and berm carry a 10 inch fuel pipeline to unload tankers.

The Millhaven tank farm, which has a capacity of 500,000 barrels, has a direct line leading to the adjoining Terylene plant of Canadian Industries Limited.

Westinghouse Scatter System

Canadian Westinghouse developed the long-range communication system — super-high frequency "scatter" communication equipment which is being supplied to the U.S. Air Force for use in the Bomarc project. This is part of $10 million contract awarded the Westinghouse Electric Corporation in the U.S.

Canadian Westinghouse is also supplying to the U.S. Air Force scatter commmunications equipment which will go into service in a tactical system.

Correction!!

A mistake was made on page 90 of the May issue of *The Engineering Journal*. The sentence reading, "Hudson Bay Mining & Smelting closed early in 1958, but it is expected to re-open early in 1959." should have read: "Britannia Mining and Smelting closed early etc., etc."

CORRECTION from February issue of *The Engineering Journal* concerning **K. D. Sheldrick.** *(see author's page).*

In 1942 he joined the Canadian Army, serving in R.C.E.M.E. in the regular army until 1946, and in the reserve from 1950 to 1958. In 1958 he retired as Commanding Officer of the 3rd Technical Regiment R.C.E.M.E., C.A. (Militia) with the rank of lieutenant colonel.

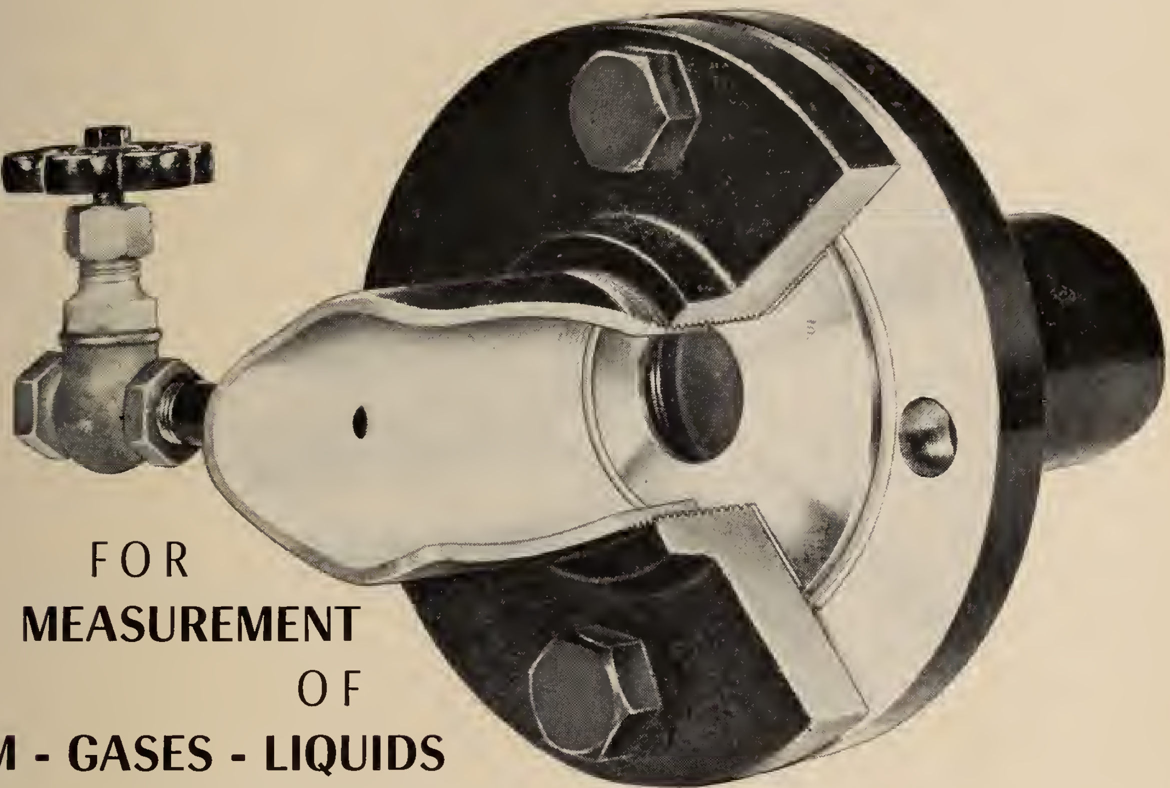
In 1946 he returned to the Bailey Meter Company.

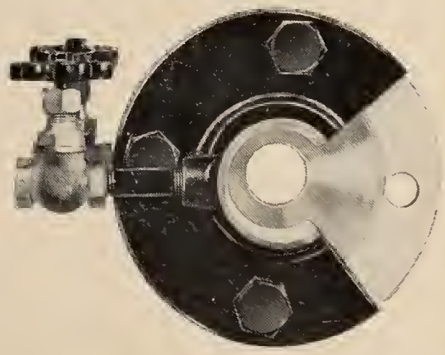
NEXT ISSUE

of

TRANSACTIONS

VOL. 3, No. 2 JULY





ANNUAL GENERAL MEETING

(*Continued from Page 103*)

ing, Past-President Ira Macnab had described the move to confederation as the biggest interpretation of what engineering is and what it stands for. And Professor Long's appeal had been anticipated by that alert octogenarian, Dr. Lillian Gilbreth, Hon. M.E.I.C., addressing student delegates the day before. Aware that the intensive development of engineering knowledge and techniques imposes a need for earlier and more thorough specialization, Dr. Gilbreth stressed the importance of finding the right girl to marry and delegating to her some of the responsibilities in the human relations field. Rather more seriously, she concluded that there is really just one answer: lifelong learning.

On the eve of the ballot on confederation the profession was undoubtedly taking stock of itself. The societies that speak for the engineer contemplate the prospect of their fusion with an evident awareness that this union is for adults only. And the attainment of majority, for the group as for the individual, implies much more than mere self-administration. With maturity comes social responsibility.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

A jury consisting of fifty readers of the *Journal*, voted the Imperial Oil Company four-colour insert the best in the April issue from the viewpoints of ACCURACY - INFORMATION - ATTRACTION. It appeared on pages 33 and 34 of the issue.

The readers who served on the jury were selected so that all provinces would be represented.

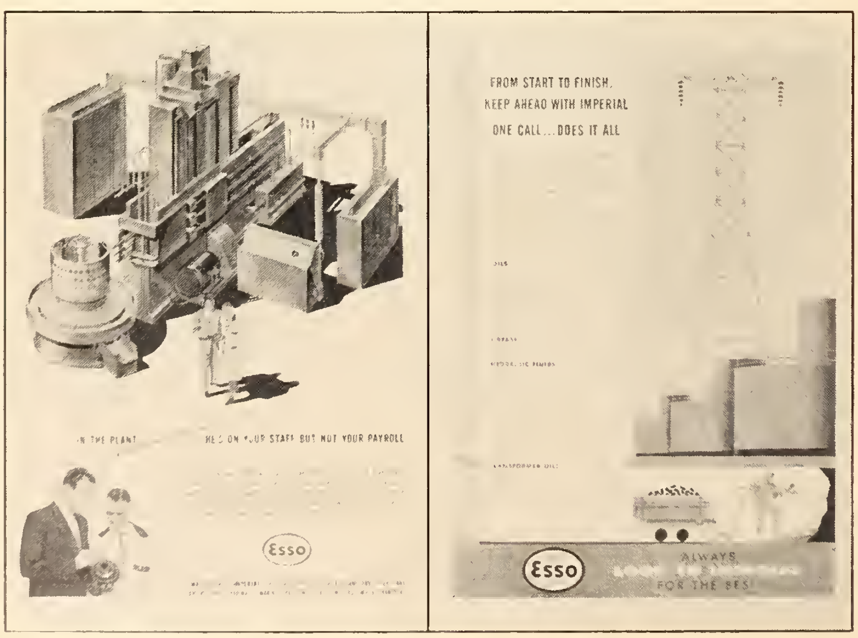
Each month the *Journal* mailing lists are used for the selection of names of jurors — five names are selected, at random, from each provincial listing. The selectees forward their votes to E.I.C. Headquarters by mail.

The number of completed returns by the jurors has been consistently large since the award of certificates was commenced at the beginning of this year The latest returns bring the average monthly number to forty-two.

It is the belief of the Institute that this method of judging advertisements in the *Journal* will be of value to the readers as it will give the advertisers a clear indication as to the type of advertisement most useful and attractive to Canadian engineers. The Institute is grateful for the co-operation of all readers who have served as jurymen.

WINNING IMPERIAL OIL ADVERTISEMENT

The Imperial Oil four-colour, two-page advertisement was judged the best in the April issue from the viewpoint of ACCURACY-INFORMATION-ATTRACTION. A certificate to that effect has been awarded to the Company. The advertisement was prepared and placed by the Toronto office of Cockfield Brown and Company.



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 15, 1959.

Member: J. L. Ballantyne, Montreal; F. A. G. Dreville, Montreal; G. G. Hatch, Toronto; C. S. Kindersley, Calgary; D. C. McMillan, Moose Jaw; W. A. Orr, St. Catharines; A. V. Price, New York; J. A. Smith, Montreal; D. C. Stephens, Toronto; J. G. Trimble, Montreal; K. R. Warren, Jamaica; G. E. Waters, Montreal; G. L. White, Montreal; L. M. Yarberry, Montreal.

Junior: D. M. Buchanan, Montreal; C. J. Chang, Montreal; G. Lahaise, Montreal; E. V. Leon, Montreal.

Affiliate: W. A. Young.

Junior to Member: A. E. Benn, Montreal; L. R. Boutilier, Sydney; J. R. Burton, Cornwall; W. M. Campbell, Kingston; C. H. Murdoch, Montreal; W. Naumko, Toronto; W. W. Popiel, Winnipeg; W. J. Smith, Welland.

Student to Junior: W. Larson, Montreal.

STUDENTS ADMITTED

University of New Brunswick: W. M. Sherrard.

University of Alberta: R. D. Cameron, J. D. Mathews, S. B. Mellsen.

St. Francis Xavier University: D. J. G. Heroux, J. M. Tremblay.

Dalhousie University: D. A. Athanassopoulos, H. M. Leonard.

University of Toronto: F. E. Collins.
McGill University: G. B. Allan.

University of Manitoba: C. E. Lamont.

St. Mary's University: L. H. McIntyre.
Nova Scotia Technical College: J. C. Martin.

University of Western Ontario: J. H. Shortreed.

University of Sherbrooke: A. Giguere.

Imperial College, London, Eng.: D. G. T. Rees.

Student of C.P.E. Quebec: P. Lukas.

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: A. Van Raalte; **Junior to Member:** D. M. Norum.

SASKATCHEWAN

Members: R. E. Bradfield, W. A. Burgess, C. J. Cameron, T. L. Carey, R. A. Purvis, W. A. Seedorf, P. M. Tyman; **Junior to Member:** B. H. Hamilton, R. S. Lang, A. Masuk, A. I. Reed, K. H. Wu; **Student to Junior:** G. C. Burns, D. G. Delparte, G. Goos, K. C. Lukawitsky, V. E. Worobey, J. E. Zuk; **Students:** M. Kotsakis, E. B. Lotochinski, D. R. Unroe.

NOVA SCOTIA

Member: R. W. Archibald.

MANITOBA

Member: V. W. Chorley.

• LIBRARY NOTES

(Continued from page 135)

***DIE HEBEZEUGE. VOLUME 1: GRUNDLAGEN UND BAUTEILE, 5TH ED.**

First of a three-volume set, this book deals with the basic components of cranes, hoists, etc., with the fundamental analysis and design of crane frames, and with the electrical equipment for hoisting machinery. Components covered are cables, chains, hooks and slings, shafts and bearings, brakes and couplings, gears and drives. Subsequent volumes will cover cranes and other types of hoisting machinery in greater detail. (Braunschweig, Friedr. Viewig and Sohn. 360p., 48.80 DM.)

***CIVIL ENGINEERING CONSTRUCTION**

Primarily concerned with construction problems rather than design. The section on plant covers such equipment as excavation and earth-moving, deep-drilling, tunnel work, blasting, hoisting and conveying, pumping and dewatering, pile driving, diving and air-lock equipment, and concreting. This is followed by a section on construction methods that deals with open excavations, shafts and tunnels, foundations, coffer-dams and caissons, timber and concrete construction, steel structures, bridges, roads, and river works. The concluding section deals with planning and organization of the project. (J. A. Antill and P. W. S. Ryan. Toronto, Ryerson, 1957. 626p., $15.00.)

***THE DESIGN OF PRISMATIC STRUCTURES**

Based on articles published in "Concrete and Constructional Engineering", this volume contains additional matter to make the analysis of pitched-slab prismatic structures more complete. Aspects discussed include prismatic structures of one span, multiple-bay structures, continuous prismatic structures, prismatic structures with sloping ends, and slabs with small angular change. In addition to the theoretical considerations applicable only to such structures, use is made of methods of calculation developed for other branches of structural engineering. Some of these methods include solution by relaxation, column analogy, moment-balance, and a method of combining bending and direct thrust. (A. J. Ashdown. London, Concrete Publications, 1958. 85p., $2.10.)

***ACOUSTICS, NOISE AND BUILDINGS**

A guidebook to the technical problems of acoustics from the standpoint of both the engineer and the architect. It discusses the behavior of sound in rooms; the design of rooms for speech and for music; the design of radio and TV studios; the design of high quality speech-reinforcement systems; sound insulation and noise control, including criteria and practice; sound measurement and calculation. (P. H. Parkin and H. R. Humphreys. Toronto, B.B.S., 1958. 331p., $14.00.)

***MECHANICS—PART II: DYNAMICS, 2nd ed.**

Among those aspects of the subject covered are kinematics; kinetics; force, mass, and acceleration; impulse and momentum; and periodic motion. Appendices deal with vector methods and moments of inertia. In the present edition of this work various changes have been made to make the book more useful. Greater distinction is made between absolute and relative motion analysis in the chapter on kinematics, and greater emphasis is placed on the formulation of problems in particle kinetics by means of the differential equation of motion. In the treatment of work and energy a new section on virtual work is included which not only helps in solving certain types of problems but provides a stepping stone to advanced theory. (J. L. Meriam. New York, Wiley, 1959. 420p., $5.00.)

***NOISE IN ELECTRON DEVICES**

The papers contained in this collection are the result of a course on "Noise in Electron Devices" which was held at the Massachusetts Institute of Technology. They cover the general problem of noise due to thermionic emission, the general circuit aspect of noise in microwave tubes, some of the detailed engineering solutions to the problems encountered in the design of low-noise traveling-wave tubes and space-charge control tubes, semiconductor noise, noise behavior of semi-conductor diodes and transistors, and the principles of low-noise transistor circuit design. In general stress is placed on basic physical phenomena and mathematical theory rather than on detailed design techniques. (L. D. Smullin and H. A. Haus, eds. New York, Wiley, 1959. 413p., $12.00.)

***SEMICONDUCTORS**

A thorough survey of the physical chemistry and fundamental physics of semi-conductors, with emphasis throughout on basic principles and phenomena. Following a general discussion of the subject, the authors deal with the physical chemistry of semiconductor systems, the relationship between the chemistry and the electrical and optical properties of a number of semiconductors, and the properties associated with semiconductor surfaces. Heavy emphasis has been placed on germanium and silicon, primarily because they are much better understood than other semiconductors. (N. B. Hannay, ed. New York, Reinhold, 1959. 767p., $15.00. American Chemical Society Monograph Series Number 140.)

***QUALITY CONTROL AND INDUSTRIAL STATISTICS, Rev. ed.**

The basic principles and procedures of statistical quality control are presented. Beginning with a section on the fundamentals which covers probability, frequency distributions, and sampling, the author continues with sampling inspection and control charts. The concluding part discusses statistical theory pertinent to industrial research and includes the estimation of lot and process characteristics, the theory of comparisons, analysis of components of variance, regression, analysis of covariance, and design of experiments. In this edition practically all of the material has been revised and expanded. (A. J. Duncan. Homewood, Irwin, 1959. 946p., $10.80.)

***THE RADIO AMATEUR'S HANDBOOK**

A new edition of a well-known reference work which contains practical information on various phases of radio communications, including receivers and transmitters of various power levels. Special methods of communication such as single sideband and radioteletype are also treated. The theory and practice of mobile radio equipment is thoroughly covered, and includes the fundamentals of transistor power supplies. A special feature is the section on vacuum tube characteristics which provides one of the most complete listings of characteristics and tubebase diagrams available. (West Hartford, American Radio Relay League, 1959. 584p., $3.50.)

***MECHANICAL DESIGN AND ANALYSIS**

The major part of the book consists of wide and recent selection of industrial case studies in machine design. The author's intent is to relate the text to specific design situations where the problem precedes the theory, and may be solved in a variety of ways. An analysis pertinent to each problem is given, providing a clear and coordinated background. Review material for the most part has been omitted, but certain topics which may not have been included in more elementary texts have been covered. These are limit dimensioning, materials to match job requirements, and repeated stress effects. (R. R. Slaymaker. New York, Wiley, 1959. 418p., $9.50.)

***JET PROPULSION ENGINES**

Presents the principles and problems encountered in combining components to form a complete engine. Following a discussion of the basic concepts common to most types of engines, the turbojet, turboprop, ramjet, the intermittent jets, and the solid propellant rocket engines are then considered in turn. The various sections on these engines examine those problems peculiar to each involving performance, control, testing, installation, and matching the various components. Similar analyses are presented for two of the hybrid types, the ram rocket and the jet rotor. Finally the use of atomic energy in jet propulsion and other future prospects are considered. (High Speed Aerodynamics and Jet Propulsion, Volume XII. O. E. Lancaster, ed. Toronto, Saunders, 1959. 799p., $23.00.)

• LIBRARY NOTES

°DESIGN OF PHYSICS RESEARCH LABORATORIES

Papers dealing with various aspects of design, including problems in the planning of research laboratories, trends in the design of American industrial research facilities, services and facilities from the user's point of view, buildings and services from the viewpoint of laboratory maintenance, and research on the design of laboratories. Numerous illustrations are included. The papers were given at a symposium held in England in 1957. (The Institute of Physics. New York, Reinhold, 1959. 108p., $4.50.)

°GUIDED MISSILE ENGINEERING

The basic principles and engineering techniques of various scientific fields are reviewed with particular emphasis on their application to guided missile design. Various sections of the book cover such fields as guidance theory, aerodynamics, electronics, airframe performance, computer systems, radio and radar, and flight simulators. Systems engineering aspects are stressed throughout the book which attempts to place in perspective the relationships between specialized fields and overall missile design. (Ed. by A. E. Puckett and S. Ramo. Toronto, McGraw-Hill, 1959. 497p., $11.50.)

°HEATING, VENTILATING, AND AIR CONDITIONING GUIDE, 1959

A revised edition of a standard handbook which covers environment, comfort, and physiological principles; heating and cooling loads; room heating and cooling methods and equipment; air systems and equipment; steam and water systems and equipment; heat generating methods and equipment; refrigeration, spray apparatus, and sorbents; controls, instruments and motors; and industrial systems. Five new chapters have been added on high temperature water systems, the heat pump, evaporative apparatus for heat rejection, evaporative air cooling and humidification, and snow melting. In addition extensive changes have been made throughout the volume. A feature of the guide is the extensive references provided with each chapter and a separately paged buyer's guide of over four hundred pages. (New York, American Society of Heating and Air-Conditioning Engineers, 1959. 768p., $12.00.)

°ROCKETRY AND SPACE EXPLORATION

Following a brief, non-technical explanation of the operation of rockets, a complete history of their development is given. The book begins with the origins of rocketry in the 1930's and continues with the Axis war rockets of World War II, and such post-war developments as the Atlas, Titan, Thor, Nike, X-15, Sputniks, Vanguard and Explorers. Concluding chapters deal with the efforts made towards international cooperation in astronautics, and with the work of such societies as the American Rocket Society and the British Interplanetary Society. (A. G. Haley. Toronto, Van Nostrand, 1958. 334p., $8.00.)

°SYMMETRICAL COMPONENTS

Presentation of the theoretical and practical aspects of symmetrical components as a means of determining the performance of electrical apparatus under unbalanced loads. The methods for calculating short circuits in computing currents and voltages in polyphase systems during fault conditions are explained in detail while other applications of symmetrical components are examined, including regulation, stability, and relaying problems of electric power networks. Stress is placed throughout the book on the use of mathematics and the corresponding physical interpretation as a means of achieving mastery of the subject. (G. O. Calabrese. New York, Ronald, 1959. 464p., $12.00.)

°MATERIALS FOR ROCKETS AND MISSILES

Presents typical engineering data on lightweight, high temperature materials. Existing metal and ceramic materials are surveyed and those materials which are expected to become available during the next few years are indicated. Materials are compared according to their chemistries and selected physical properties such as density, coefficients of thermal expansion and conductivity, elastic moduli, and impact strength. New material fabrication processes, including high temperature brasing, chipless production, and unconventional machining techniques are also covered. Sheet, wrought, and cast alloys with iron, nickel, and cobalt bases are covered, as are wrought and cast alloys of aluminum and magnesium, titanium alloys, cermets, molybdenum alloys, and ceramics. (R. G. Frank and W. F. Zimmerman. Galt, Brett-Macmillan, 1959. 124p., $4.50.)

°THE DESIGN OF LAND DRAINAGE WORKS

Papers on a variety of aspects of flood protection and alleviation, groundwater level control, water conservation, irrigation, and protection of low-lying land against the sea. They are intended to provide a concise reference for everyday use by design engineers, and include such topics as flood hydrographs, hydraulic calculations for channel improvement schemes, flow in alluvial channels, fluming for land drainage works, tidal outfalls, automatic radial sluice gates, land drainage pumping stations, and earthen flood banks. Each paper is accompanied by explanatory notes that serve both as an introduction to the paper and as a means of supplementing the information contained in it. (R. B. Thorn. Toronto, Butterworth, 1959. 235p., $7.00.)

°RELIABLE ELECTRICAL CONNECTIONS. PROCEEDINGS OF THE THIRD EIA CONFERENCE, 1958

The latest developments in the design and application of electrical connections are discussed. The results of investigations are given in thirty-two papers dealing with fixed connections, disconnect connections, soldered connections, pressure connections, wire-wrap connections, welded and ultrasonic connections. Several papers cover aspects of connections in relation to printed circuits. (New York, Interscience, 1958. 286p., $7.75.)

°FILLER METALS FOR JOINING

A presentation of the factors influencing the choice of a filler metal for any given metal joining situation. All of the recognized ferrous and nonferrous joining metals for welding, brazing, and soldering are discussed. Available materials are discussed in terms of applicability, mechanical properties, and degree of availability. The major portion of the book is devoted to arc welding electrodes, while the remainder deals with such topics as automatic welding of mild and low alloy steels, the new iron powder electrodes, recent developments in nonferrous metals, surfacing, and tungsten electrodes. (O. T. Barnett. New York, Reinhold, 1959. 244p., $7.00.)

°WELDING OF PLASTICS

The physical and chemical properties of individual plastics presently used for welded construction are discussed in relation to their use in chemical and allied processing. The various techniques of welding used are also discussed, and detailed procedures are given accompanied by suitable illustrations. Features of the volume include complete corrosion resistance tables and a concise guide to the choice of an appropriate plastic construction material. Two complete chapters are devoted to design considerations as they affect welded construction, and to testing and evaluation. (J. A. Neumann and F. J. Bockhoff. New York, Reinhold, 1959. 279p., $7.25.)

°FUNDAMENTAL ASPECTS OF REACTOR SHIELDING

Stress is laid on the fundamentals of the subject, specifically the factors affecting the permissible radiation levels, the sources and characteristics of the radiation to be shielded against, and how bulk shielding measurements are made. The book concludes with a detailed analysis of the calculations necessary to determine, theoretically or empirically, the attenuation of neutron and gamma rays in shield materials. Although certain related fields such as radiation biology and nuclear physics are considered, a background knowledge on the part of the reader is assumed. (H. Goldstein. Reading, Addison-Wesley, 1959. 416p., $9.50.)

E.I.C. Annual General Meeting, 1960, Winnipeg, Man., May 25-26-27

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

AUGUST 1959

vol. 42 no. 8

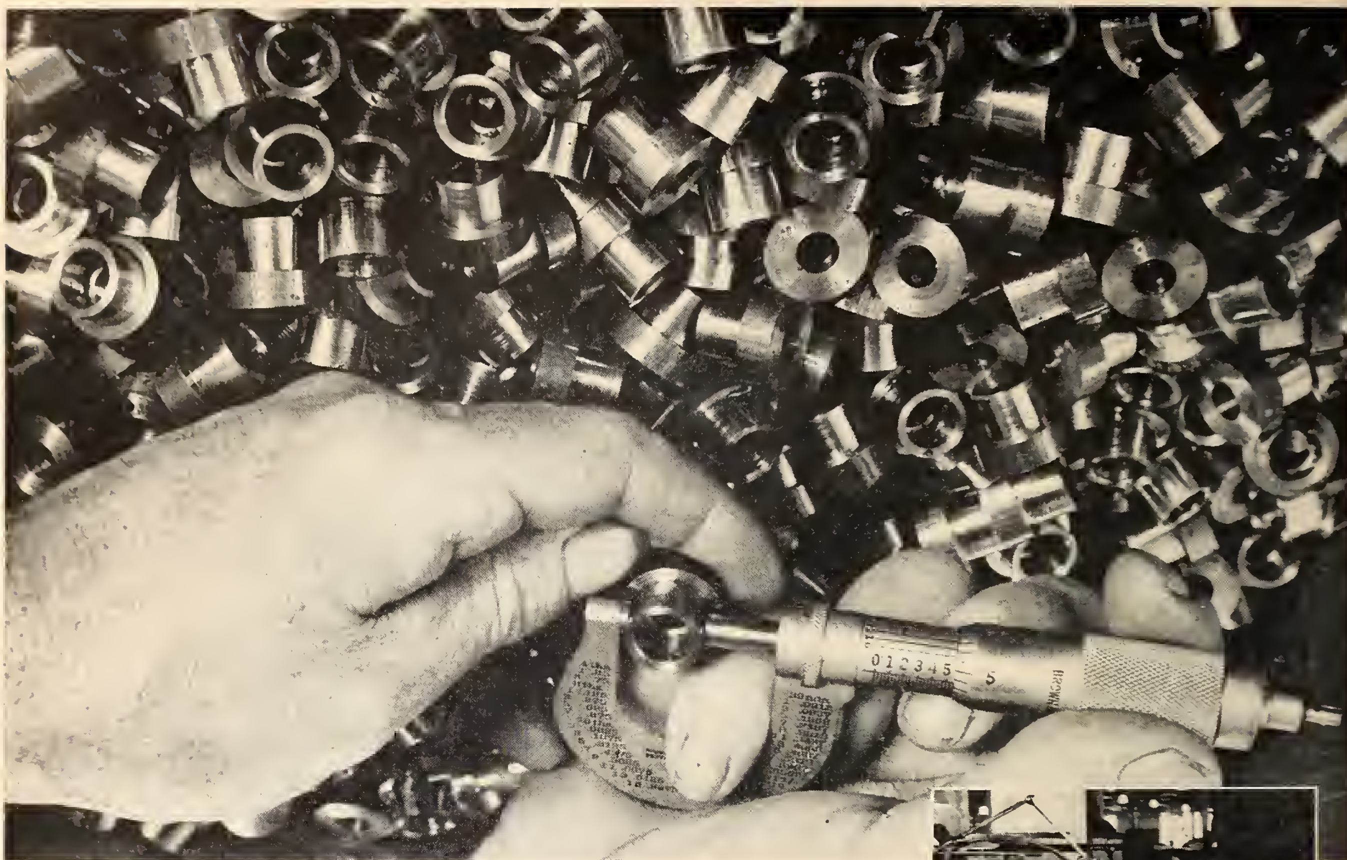
Cables: Enginst-Montreal
PRINTED IN TORONTO

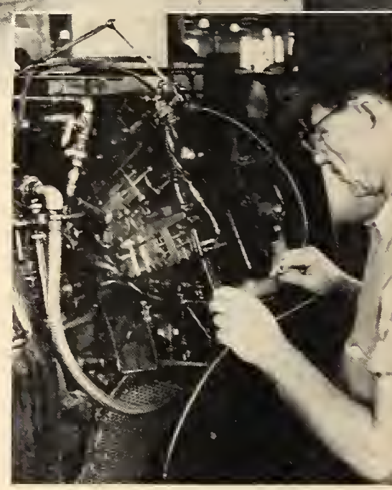
Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

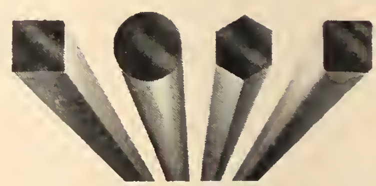
MEMBERSHIP

Indexed in
The Engineering Index
The Applied Science and Technology Index
The Canadian Business and Technical Index.

(19,800 copies of this issue printed)



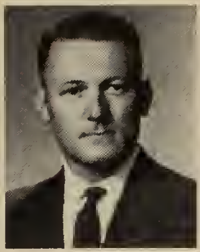




MEET THE AUTHORS

W. H. Sanders, manager, data communications and control, The Hydro-Electric Power Commission of Ontario (*Headquarters Computation Centre for Ontario Hydro).*

Mr. Sanders graduated in engineering physics at the University of Toronto in 1950. In 1955 he was appointed to a study team to report on the feasibility of electronic data processing and upon completion of the study was made responsible for the specification of input equipment and the design of error detecting techniques. He has held his present position since 1958.



S. J. Crossman, supervisor, design of teletypewriter switching systems, The Bell Telephone Company of Canada *(Headquarters Computation Centre for Ontario Hydro).*

Mr. Crossman was born and educated in Toronto, graduating from the University of Toronto in 1951 with a B.A.Sc. in electrical engineering after serving with the R.C.A.F. in the communications field. He was loaned to the Western Electric Company for a year during the installation and testing of the Distant Early Warning Line in Alaska and the Yukon.

On returning to The Bell Telephone Company he took part in the engineering of the Mid Canada Early Warning Line.

He is a member of the Corporation of Professional Engineers of Quebec and the Association of Professional Engineers of Ontario.

John Rywak, member, Scientific Staff, Northern Electric Research and Development Laboratories, Belleville, Ontario, *(Headquarters Computation Centre for Ontario Hydro).*

Mr. Rywak is a graduate in Electrical Engineering of the University of British Columbia. After service with the Royal Canadian Air Force he joined the Northern Electric Company in 1950 and during his service with this Company has been responsible for some ten patent applications.

Mr. Rywak is a senior member of the Institute of Radio Engineers and a member of the Association of Professional Engineers of Ontario.

At time of going to press no information was available on **Mr. H. Ross W. Davis** a co-author of the paper, *(Headquarters Computation Centre for Ontario Hydro).*

Dr. J. T. Hugill, M.E.I.C., M.B.E., manager, field operations and construction, L'Air Liquide (*A Large Capacity Oxygen Plant for Copper Refining*).

Dr. Hugill was born in Calgary, he graduated from Royal Military College and served with Canadian Army Overseas in chemical warfare. He was awarded M.B.E. in 1945 and joined L'Air Liquide in 1946.

Dr. Hugill is a Fellow of The Chemical Institute of Canada; a member of The American Chemical Society; The American Institute of Chemical Engineers and is a registered professional engineer in Quebec.

W. G. H. Holt, M.E.I.C., general manager of the mechanical division, Dominion Bridge Company Limited. *(Design and Erection Features of the Vertical Lift Bridges for the St. Lawrence Seaway Authority.)*

Mr. Holt graduated from the University of Toronto in 1936 as a mechanical engineer and began his career with the Dominion Bridge Company at Lachine where he gained experience in the mechanical drawing, design and sales offices, as well as in the production department. He was appointed Mechanical Engineer, Eastern Division in 1954, the position he held until his recent appointment this year.

He is a member of the Corporation of Professional Engineers of Quebec and The American Iron and Steel Engineers.

R. F. Scott, M.E.I.C., assistant professor in civil engineering, California Institute of Technology, *(Oil Tank Sites Preloaded by Well Point System).*

Dr. Scott was educated at Glasgow University, Scotland before coming to the United States to study and carry out research at M.I.T. He worked for two years for the Arctic Construction and Frost Effects Laboratory of the U.S. Army Engineers and in 1957 came to Canada to take up employment with Racey, MacCallum and Associates, Ltd. as divisional soils engineer. He is an associate member of the American Society of Civil Engineers.

P. E. Cavanagh, vice president, Premium Iron Ores, Montreal *(Processing of Low Grade Iron Ore Using Natural Gas or Petroleum).*

Mr. Cavanagh graduated from the University of Toronto in 1937 with a B.A.Sc. in Metallurgy. He worked with the Steel Company of Canada, Hamilton, for five years and with Allan B. Dumont Laboratories, Passaic, N.J. for three. He was with the Ontario Research Foundation for nineteen years, five of which he directed the Department of Engineering and Metallurgy.

Mr. Cavanagh has presented papers through all major societies and sat on committees such as A.I.M.M.E., A.S.T.M., and A.S.M. He has also been on U.N. Committees.

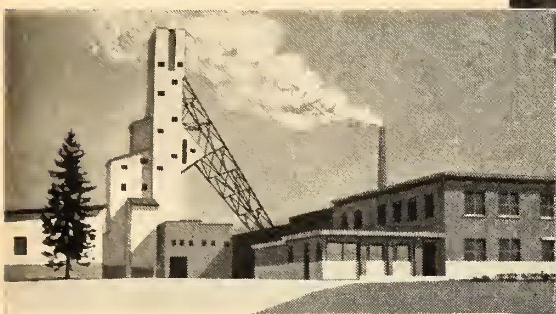
OMITTED FROM JULY ISSUE

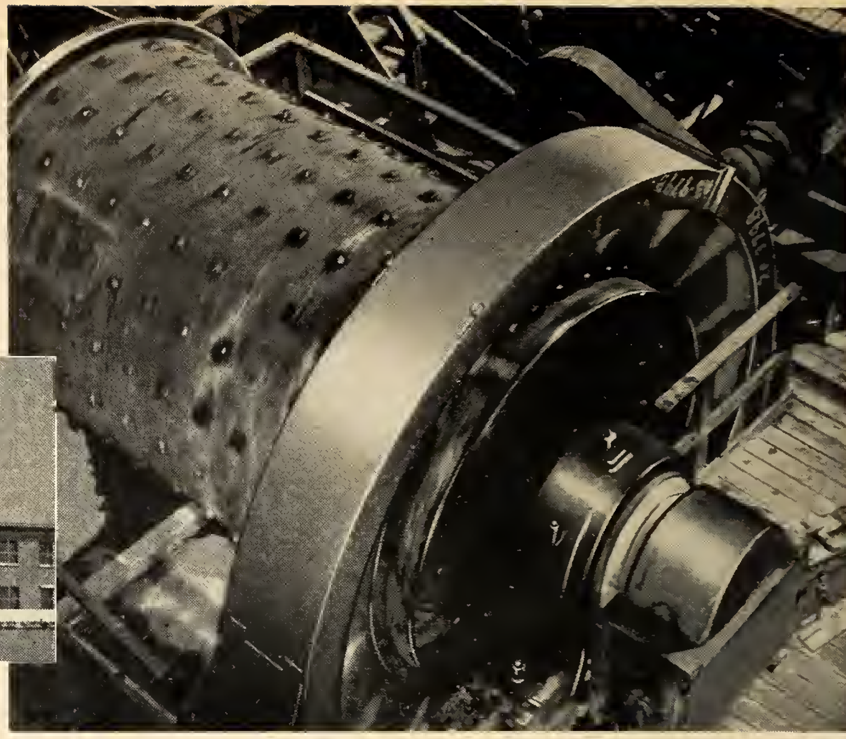
R. A. Walker, assistant hydraulic engineer, (studies) The Hydro-Electric Power Commission of Ontario *(Headloss Coefficients for Niagara Water Supply Tunnels).*

Mr. Walker graduated from the University of Toronto in 1943 with B.A.Sc. in mechanical engineering. He served as demonstrator in hydraulics at the University of Toronto 1943-44 and almost two years in the Royal Canadian Navy as engineer officer. In 1946 he joined the Hydraulic Department of the Ontario Hydro as junior engineer. In his present position he has charge of hydraulic field tests on turbines and structures, hydraulic resource estimates, storage regulation studies and hydrometric office and field investigations. He is a member of the Association of Professional engineers of Ontario and an associate member of the American Society of Mechanical Engineers.

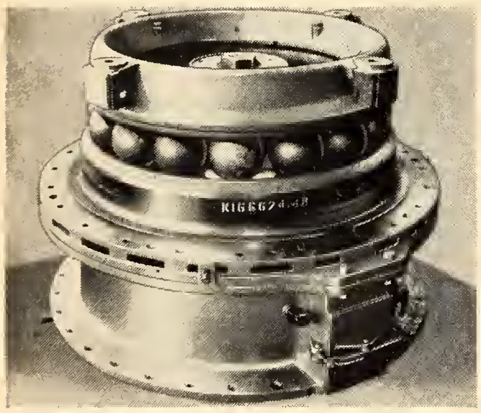
Our cover picture shows the interior of the main product pumphouse at the Hamilton Tar Plant of Dominion Tar and Chemical Company Limited, (Coal Tar Products Division)

Kerr-Addison Gold Mines, Limited, replaced forged steel grinding balls with Ni-Hard cast iron grinding balls in this ball mill shown at right, resulting in a saving of 20.1% in overall wear . . . cutting costs 14.8%.





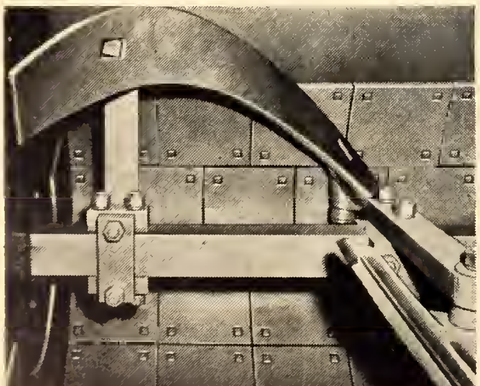
NI-HARD*cast iron cuts costs and reduces wear in abrasive applications



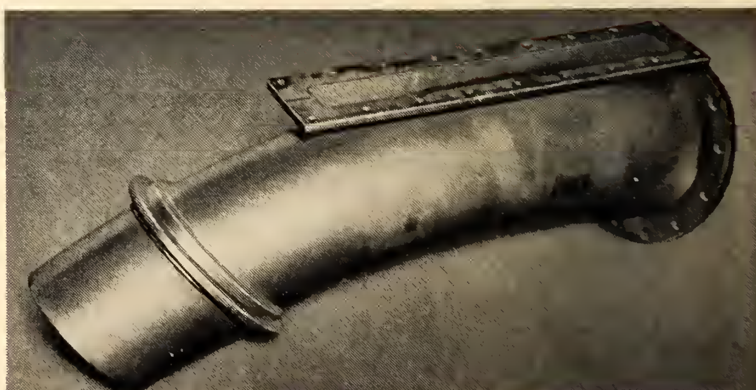
Ni-Hard grinding rings used in this coal pulverizer outlast white iron three to five times.

Ni-Hard is a nickel-chromium white cast iron with high abrasion resistance. It has many money-saving, wear-saving uses in mining, power, cement, ceramics, paint, dredging, coal-coke, steel, foundry and other industries—where abrasion is a problem.

**Trade Mark*



Ni-Hard paddles and liner used in cement block mixing machines give better than six to one service life over previous abrasion resistant material.



This cement slurry elbow of Ni-Hard cast iron replaced original equipment which had failed after three months' service. The Ni-Hard elbow is still giving excellent service after five times the service life of previous material.

HEADQUARTERS COMPUTATION CENTRE FOR THE H.E.P.C. OF ONTARIO

The Design of the Data Communication Network

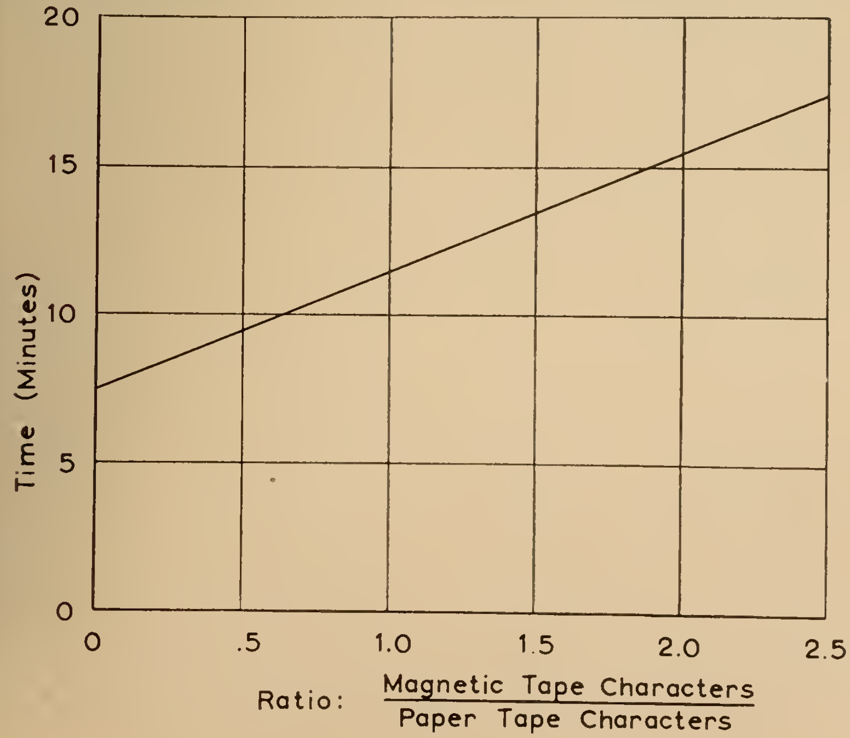
W. H. Sanders.

Manager, Data Communications and Control Dept., The Hydro-Electric Power Commission of Ontario.

THE ONTARIO HYDRO is a public utility which produces and distributes electric power throughout the Province of Ontario. There are two distinct phases of operation; the first is the provision and delivery in wholesale quantities of electric power to municipal utilities and large industrial customers, the second is the distribution of power to the ultimate customer. The distribution of power in most municipalities is conducted by municipal utilities. In rural areas and in a small number of municipalities, the Ontario Hydro operates and administers the distribution facilities.

For administrative purposes, the Province is divided into nine regions and the regions are subdivided into 103 rural operating areas. While the administration of the system is decentralized, certain areas of data processing are handled on a centralized basis.

Chart 1. Time required to convert 900 ft. of paper tape to magnetic tape (excluding handling time).



In August of 1955, the Commission authorized the establishment of a team to study Electronic Data Processing. The report of this study team recommended that the Commission centralize and integrate its data processing, enter the field of electronic data processing using a large-scale digital computer, capture input data on five channel punched paper tape at the initial recording (where economically possible) and transmit this information by wire to the data processing centre. The reports of the system were to be printed on high speed printers in the processing centre and mailed to the Area and Region offices.

The original concepts concerning the application of electronic computing machinery to commercial data processing followed two divergent paths, the information machine and the production machine. The study team recommended that the latter concept be used and that information be ordered prior to processing. The data would enter the system mechanically as a by-product of initial recording in a form not requiring further human intervention without destroying administrative and financial controls. Area offices would require the facility to enter data into the processing system and to produce a legible record. These offices would then transmit the information to their respective Region offices. The transmission of information in these nine networks would be one-way.

Due to the large number of Area offices, compared to the number of Region offices, and the fact that 90% of the original data is numeric, economy could be obtained by limiting the Area office to the entry of numeric data and requiring the Region office to enter all alphabetic data. This would be feasible providing the scheduling problem created by requiring alphabetic data to be mailed to Region offices could be overcome. The Region offices would be equipped with tape-reading typewriters to print out data contained in the tapes received from Area offices. This arrangement would provide the Region staff with the facilities to audit the accuracy of data forwarded to Head Office by exercising quality control using a statistical sampling basis, and to assure that only legitimate data is handled and that all data is processed. These offices would then relay information to the data processing centre.

The final stage in the data communication network would be the conversion of information from the medium of punched paper tape to the medium of magnetic tape.

Design of the System

The design of our data communication network was influenced by the need to maintain the concepts of decentralized administration, the capabilities of the basic input devices and the paper tape to magnetic tape converter, and the requirement for the detection and correction of errors.

One of the primary functions of an Area office is to provide customers with service. If this function was not to be disturbed, data transmission would be random rather than stringently scheduled. Information would have to be identified as to particular process involved and sorted prior to processing. This sort could be carried out on the computer or prior to entering the computer. If it were sorted on the computer, all data would have to be converted onto magnetic tape before any data could be processed. If the sort occurred before the conversion to magnetic tape, certain data could be given preferential treatment in the conversion to magnetic tape and one class of data could enter the processing system while another class was undergoing conversion. Data which was late in arriving in the processing centre could by-pass the normal conversion procedure and enter the central computer in time for processing. It would be possible to use more than one scheme of conversion to magnetic tape. This would permit error detection on the paper tape converter and thereby start correcting procedure at an earlier point in the processing cycle, and would reduce the time required for conversion and the time required to initially read the magnetic tape on the computer. It was decided to allow the Area offices to transmit data in a random order and to sort the data prior to conversion to magnetic tape.

The numeric input device in our data processing system is a Monroe duplex auto-punch. Numeric data can usually be segregated into data which identifies and data which quantifies. To detect errors in the keying of data, the identifying data carries along with it a check digit. This check digit has the property that the identifying data, including the check digit, is some multiple of seven. All identifying data is accumulated in one register of the machine and totalled at the end of each section of a message. Quantitive data is accumulated in the second register and also totalled at the end of each section of a message.

Prior to the transmission of the message, the totals of both registers are checked, the identifying data totals are checked for divisibility by seven, while the quantitive data totals are checked by accounting controls, i.e., total cash reported as collected from customers agrees with the total cash deposited in the bank. After these checks have been performed, the message is transmitted. If an error was detected, a correction message is prepared which, in the computer processing, will delete the item in error and insert the correct information. Since the paper tape message was prepared as a by-product of the initial recording, all correction messages must not only adjust the computer processing, they must also adjust the original hard copy to complete the information on file in this office and thereby facilitate the auditing of accounts.

Provision has also been made to correct information within the message if the error is detected either before the motor bars of the auto-punch have been depressed or after the motor bar is depressed but before the message is terminated. In the latter case, the procedure is similar to that of a correction message.

Errors in the transmission of data from the originating office to the data processing centre in which a decimal character changes to another decimal character are detected in the initial computer run by comparing the arithmetic sum of the data received with the transmitted sum. Identifying data which is common to a number of items of data, such as the particular process involved, date and originating office, is not entered into the accumulating registers. The ease with which keying and transmission errors can be detected is dependent upon the redundancy of the data. To protect that numeric data in which errors are not easily detected, the redundancy is increased by the insertion of the 9's complement. In this way, the information is duplicated without the use of the same keying configuration.

To detect the loss or gain of characters during the transfer of data to the computer and to simplify the control mechanisms on the input machines, the format of messages is strictly controlled. To detect the loss or gain of a character in the body of a message, it was decided to transmit information in groups of 60 characters, each group to fill one line of printing on the page printers. This, in turn, meant that the length of a line of printing was predictable and could be automatically controlled. During the time required for the

Table 1. Format Control.

No. of words in item of information	*Total No. of possible combinations of word lengths*	*Total No. of acceptable combinations of word lengths* — *Area × Region Network*	*Region × H.O. Network*
I All possible combinations of word lengths			
1	20	6	12
2	200	28	56
3	600	48	96
4	1200	72	144
II Excluding those combinations where any word contains less than 3 characters			
1	16	4	8
2	128	15	30
3	384	24	48
4	768	30	60

carriage to automatically return one or two characters could be received. If these characters are non-printing characters, there is no loss of information on the printed copy. If the characters are printing characters, over-printing will occur, a condition easily detected by visual inspection.

The auto-punch was designed to punch one function code character preceding the digits entered in the keyboard and another function code character following these digits. These additional characters are used to identify which motor bar was depressed and to control the paper tape to magnetic tape converters and the monitor page printers. The function code characters, following the entry of information in either register of the auto-punch, are non-printing characters.

Within the body of a message, each line of printing must contain an integral number of entries into the accumulating registers and each line contains 60 characters. To reduce the time required for transfer of information to the computer, the auto-punch is equipped with two switches which determine the number of digits to be punched when information is entered into one of the two registers of the machine.

Format control places a restriction on the number of possible combinations that can be transmitted. (See Table I). It provides a fast visual check that the operator has correctly set the input machine and characters have not been lost or gained in the transmission of data. It is also possible by visual inspection to detect the large majority of errors where decimal character changes to other than a decimal character.

One of the problems encountered in the transmission of information is the receipt of a blank character. All monitor page printers will space on a blank. If the blank is an additional character, spacing will distort the format and is easily detected, but the substitution of a blank for another character is not easily detectable by a fast visual inspection. All receiving points are equipped with blank detectors. When a blank is received, the transmission of the message is stopped and the message is retransmitted.

Data is not only sorted by the particular process involved, it is also sorted by whether it is numeric or alpha-numeric, and use is made of the paper tape to magnetic tape converter to detect illegal characters. In a parity check, one half of the total number of possible coding combinations is legal and the other half

CASH MESSAGE—CORRECT

```
 *1089381108
 *0322800005
 *0000000990
 *6025381100
#00207802   +00003510   #00209202   +00002492   #00251405   +00002857
#00254303   +00003167   #00200606   +00000986   #00200802   +00003221
#00201404   +00003100   #00201901   +00003221   #00202006   +00003653
#00202104   +00003248   #00202300   +00004706   #00202601   +00003707
#00202902   +00003937   #00203602   +00001053   #00204001   +00002776
#00206605   +00000648   #00208600   +00004571   #00208705   +00004747
#00209405   +00004976   #00209601   +00001408   #00209804   +00004342
#00209902   +00002492   #00211603   +00002285   #00211701   +00002681
#00211806   +00004315   #00211904   +00004963   #00213101   +00002438
#00213206   +00000405   #00213801   +00002857   #00214305   +00007150
#00214501   +00000607   #00215005   +00005611   #00215103   +00004085
#00236600   +00002533   #00237503   +00004936   #00238602   +00002819
#00239106   +00002006   #00239505   +00002371   #00240604   +00004382
#00243201   +00003343   #00244202   +00003383   #00245000   +00004120
#00245301   +00001548   #00245700   +00003059   #00246106   +00003248
#00251006   +00003451   #00252000   +00003275   #00252203   +00002479
#00252406   +00003532   #00252903   +00003667   #00254002   +00002795
#00254205   +00003505   #00255101   +00001057   #00206003   +00004455
#00254401   +00004085    *6025381100

0012341259
+0000176264:
 *0000000990
 *5025381100
#00200102   +00003084   #00251300   +00001545   #00208404   +00000675
#00254905   +00001462   #00239701   +00001564   #00240506   +00002162
#00246701   +00007389   #00205604   +00004374   #00210301   +00002000
#00238805   +00005019   #00242900   -00003000   #00253603   +00000675
 *5025381100

0002792832
+0000026949:
 *0000000990
 *1273381100
#00242900   +00003000    *1273381100

0000242900
+0000003000:
```

CASH MESSAGE—ONE CHARACTER LOST IN LINE 14

```
 *1089381108
 *0322800005
 *0000000990
 *6025381100
#00207802   +00003510   #00209202   +00002492   #00251405   +00002857
#00254303   +00003167   #00200606   +00000986   #00200802   +00003221
#00201404   +00003100   #00201901   +00003221   #00202006   +00003653
#00202104   +00003248   #00202300   +00004706   #00202601   +00003707
#00202902   +00003937   #00203602   +00001053   #00204001   +00002776
#00206605   +00000648   #00208600   +00004571   #00208705   +00004747
#00209405   +00004976   #00209601   +00001408   #00209804   +00004342
#00209902   +00002492   #00211603   +00002285   #00211701   +00002681
#00211806   +00004315   #00211904   +00004963   #00213101   +00002438
#0021306   +00000405   #00213801   +00002857   #00214305   +00007150 #
 00214501   +00000607   #00215005   +00005611   #00215103   +00004085 #
 00236600   +00002533   #00237503   +00004936   #00238602   +00002819 #
 00239106   +00002006   #00239505   +00002371   #00240604   +00004382 #
 00243201   +00003343   #00244202   +00003383   #00245000   +00004120 #
 00245301   +00001548   #00245700   +00003059   #00246106   +00003248 #
 00251006   +00003451   #00252000   +00003275   #00252203   +00002479 #
 00252406   +00003532   #00252903   +00003667   #00254002   +00002795 #
 00254205   +00003505   #00255101   +00001057   #00206003   +00004455 #
 00254401   +00004085    *6025381100

 0012341259
+0000176264:
 *0000000990
 *5025381100
#00200102   +00003084   #00251300   +00001545   #00208404   +00000675
#00254905   +00001462   #00239701   +00001564   #00240506   +00002162
#00246701   +00007389   #00205604   +00004374   #00210301   +00002000
#00238805   +00005019   #00242900   -00003000   #00253603   +00000675
 *5025381100
 0002792832
+0000026949:
 *0000000990
 *1273381100
#00242900   +00003000    *1273381100

0000242900
+0000003000:
```

illegal. In the paper tape to magnetic tape converter, this restriction does not apply. Any code combinations can be declared legal or illegal.

During the conversion of numeric messages, those characters which can be produced on the auto-punch, together with three characters required to indicate the end of data on a magnetic tape, are legal and are converted. All other characters are considered illegal, and the conversion stops. The paper tape is marked and the remaining paper tape is processed through the converter to detect errors in this section. The paper tape is returned to the communication operators for correction.

In the conversion of alpha-numeric messages, 60 of the 64 possible code combinations are considered as legal and this form of detection cannot be applied. Excluding the blank characters, two of the remaining 62 characters cannot be obtained on the alpha-numeric input machine, and are considered illegal combinations. One of these two characters is a function code on the numeric input machine. This arrangement prevents the bypassing of the illegal character tests when converting numeric messages.

Data is organized in the Univac system in fixed word lengths. The paper tape to magnetic tape converter changes the organization of data from the variable word format on paper tape to fixed word format on magnetic tape. The speed of conversion is a function of the ratio of the number of magnetic tape characters to the number of paper tape characters. (See Chart I). It is obvious that the length of time required to convert a given message and the length of magnetic tape produced can be reduced by employing more than one conversion scheme on numeric messages. Messages are therefore sorted by the system employed to convert messages to the medium of magnetic tape.

The format of data on magnetic tape can be controlled by a sequence of one, two or three characters. On the assumption that an error can produce any of the 64 characters, the more important functions of the converter are controlled by two or three characters in sequence. Two characters are used to activate the start convert function and three characters are used to activate the stop convert function.

In the initial computer runs, the format of the information on magnetic tape is checked, totals are checked against the detailed data and the indicative data is checked for divisibility by seven. The validity of the information is also checked when the computer performs a calculation or posts the information to its files. If an error has occurred, the office that originated the data is notified and takes the necessary action required to correct this condition.

METER READING MESSAGE—BLANK SUBSTITUTED FOR A CHARACTER IN LINE 8

*1188571107							
*1231702574							
#0008400	+1742	#0000014	+0840	#0058506	+3850	#0000014	+1160
#0059703	+1043	#0000014	+0300	#0063504	+0460	#0000014	+0360
#0072205	+1488	#0000014	+0500	#0088900	+0539	#0000014	+0240
#0091301	+0411	#0000014	+0520	#0100303	+0679	#0000014	+0200
#0102704	+0528	#0000014	+0320	#0104006	+2697	#0000014	+0860
#0106302	+32 8	#0000014	+0720	#0107401	+1962	#0000014	+0940
#0120904	+0634	#0000014	+0940	#0171003	+0000	#0000014	+0000
#0171703	+1184	#0000014	+0780	#0172305	+3240	#0000014	+1000
#0173306	+2641	#0000014	+1040	#0174006	+0851	#0000014	+0640
#0175203	+5298	#0000014	+1320	#0175504	+1304	#0000014	+0440
#0176106	+1047	#0000014	+0340	#0176204	+2079	#0000014	+0720
#0176400	+4166	#0000014	+0700	#0201901	+0820	#0000014	+0100
#0204106	+0827	#0000014	+0100	#0345604	+0336	#0000014	+0640
#0410802	+4183	#0000014	+0200	#0418404	+8490	#0000014	+0140
#0419706	+1881	#0000014	+0700	#0423500	+1028	#0000014	+0400
#0425201	+0198	#0000014	+0660	#0425306	+4120	#0000014	+0520
#0425901	+2784	#0000014	+0580	#0009401	+8957	#0000014	+0300
#0430003	+1415	#0000014	+0620	#0431102	+0704	#0000014	+0760
#0007105	+0270	#0000014	+0700				
0007404439							
+0000098414:							

METER READING MESSAGE—BLANK ADDED AS AN ADDITIONAL CHARACTER IN LINE 8

*1188571107							
*1231702574							
#0008400	+1742	#0000014	+0840	#0058506	+3850	#0000014	+1160
#0059703	+1043	#0000014	+0300	#0063504	+0460	#0000014	+0360
#0072205	+1488	#0000014	+0500	#0088900	+0539	#0000014	+0240
#0091301	+0411	#0000014	+0520	#0100303	+0679	#0000014	+0200
#0102704	+0528	#0000014	+0320	#0104006	+2697	#0000014	+0860
#0106302	+3258	#0000014	+072 0	#0107401	+1962	#0000014	+0904
#0120904	+0634	#0000014	+0940	#0171003	+0000	#0000014	+0000
#0171703	+1184	#0000014	+0780	#0172305	+3240	#0000014	+1000
#0173306	+2641	#0000014	+1040	#0174006	+0851	#0000014	+0604
#0175203	+5298	#0000014	+1320	#0175504	+1304	#0000014	+0404
#0176106	+1047	#0000014	+0340	#0176204	+2079	#0000014	+0702
#0176400	+4166	#0000014	+0700	#0201901	+0820	#0000014	+0100
#0204106	+0827	#0000014	+0100	#0345604	+0336	#0000014	+0604
#0410802	+4183	#0000014	+0200	#0418404	+8490	#0000014	+0104
#0419706	+1881	#0000014	+0700	#0423500	+1028	#9999914	+0400
#0425201	+0198	#0000014	+0660	#0425306	+4120	#0000014	+0707
#0425901	+2784	#0000014	+0580	#0009401	+8957	#0000014	+0306
#0430003	+1415	#0000014	+0620	#0431102	+0704	#0000014	+0765
#0007105	+0270	#0000014	+0700				
0007404439							
+0000098414:							

Description of Equipment and its Operation

Each Area office is equipped with a Monroe duplex auto-punch, a sevens calculator, and a tape transmitter. Numeric messages are prepared on the auto-punch, the totals of each register are checked, and the paper tape is inserted into the gate of the transmitter. If an error was detected by checking the totals, the error is isolated and a correction message prepared. The transmitter is automatically started by the control equipment in the Region office when the gate is loaded and automatically stopped when the message has been transmitted. If a break occurs during the transmission, the transmitter stops, the tape must be repositioned to the start of the message and the transmitter reset. Messages are numbered sequentially through a 00 to 99 cycle and are filed. At any point in time, the originating office has on file the previous 90 messages. The first message transmitted each morning indicates the message number of the last message transmitted the previous day.

Each Region office is equipped with an automatic sequencing device, an on-line and an off-line Lorenz page printing reperforator, and a transmitter. The sequencing device automatically interrogates the Area offices until it locates an office which has loaded its transmitter, the transmitter is started and the message is received in the form of page printed copy and paper tape. The message is checked for number sequence and format. If acceptable, the paper tape is inserted into the transmitter for transmission to the data processing centre. After transmission, the paper tape is destroyed. (The hard copy received is then referred to the Region office staff to check that the appropriate authorization has been obtained and that the proper accounting distribution has been made.)

If a break occurs, an alarm is sounded, the sequencing device steps to the next Area, and the paper tape received from the first Area is destroyed. If an error occurs in the format, the paper tape is destroyed and the Area requested to retransmit the message. If on retransmission the identical error occurs, it is assumed that the original tape is in error. If the error is such that the message can be converted to magnetic tape, the message is transmitted, otherwise the Area is requested to prepare a new message. In the former case, the data processing centre is informed that the message transmitted is in error. The off-line Lorenz machine is used to prepare alphanumeric messages based on information received from the Area office.

Region offices follow procedures similar to those in effect in the Area offices for the preparation of messages. Each morning the Region operator prepares a message for transmission to the processing centre based on a sequence control card which lists the number of messages from each location sent to the processing centre the previous day.

Information is received in the data processing centre on page printers and on typing reperforators. The format is checked in a similar manner to that used in the Region office. Since sequence checking of messages is no longer practicable, the messages are tabulated by the type of message and the originating office. When sufficient tape has accumulated on the reperforators (150 ft. to 200 ft.), it is removed and the tape is inserted into one of two readers on the sorter. The sorter reads the paper tape and recognizes the double character start code, the four decimal digit message classification, and the triple character end code. Under the control of a switching panel, one of seven punches is energized and the message reperforated. One sorter can handle the output of between six and seven incoming lines due to its speed of operation and the nature of the data sorted. The sorter, which operates at eight times the speed of the incoming lines, was designed to initially recognize 50 different classifications of data.

If the total of the messages in each classification is of equal length, then a 49-way sort could be accomplished by reading each message twice. The effective speed of the sorter would be equivalent to four incoming lines. By means of the switching panel, any number of message classifications can be directed to any particular punch. Use is made of the fact that, in a given day, the total of the messages in each classification is not equal in length, by operating the sorter such that each punch is used for the same length of time. This reduces the volume of traffic requiring a second sort and effectively increases operating speed of the sorter. If the four decimal digits after a message start code are not a legal combination, the message is directed to an error punch which is associated with a transmitter and page printer. Prior to removing the paper tape from a punch, a special message is passed through the reader and directed to the punch. This message will identify the end of data on magnetic tape. A similar message is used prior to punching the first data message on a roll of tape to indicate the start of data on magnetic tape.

One reel of paper tape is then converted to one reel of magnetic tape. An error on a reel of paper tape requires the isolation of the error, its correction and a rerun of the conversion process. A reel of paper tape contains approximately 100,000 characters and each sorter processes approximately 10 reels of paper tape a day or 10^6 characters. An error frequency of 1 in 10^6 in the sorter will produce one error a day, and therefore the correction and reconversion of a reel of paper tape.

The sorter is equipped with message counters on each punch and on the reader. At the end of the processing day, the tabulation of incoming messages by message classification is agreed to the message counters on the sorter, while the tabulation of incoming messages by originating office is agreed to the control messages received from the Region offices. The initial run on the computer totals the number of messages on each input reel of magnetic tape and these totals are agreed to the sorter counters.

The hard copy from the page printers is used to post a manual control. Controls have been built into the computer system based on information received by the computer. The manual control checks that all information received over the communication network was processed and that all messages rejected from the system due to error have re-entered the processing system. In certain circumstances, the manual control will indicate those offices which have not prepared messages required for a particular process.

Communications Between Regional Offices and the Head Office and the Tape Sorting Operation

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THE DATA Communication System of the Hydro Electric Power Commission of Ontario provides the means of transmitting data from the H.E.P.C. area offices throughout Ontario via the nine regional offices to the head office in Toronto, sorting it into categories, converting it from paper tape to magnetic tape and processing it by a Univac computor. The system also provides for the transmission of administrative traffic from the head office to a number of the regional offices.

The portion of the transmission system between the area offices and the regional offices is provided by the telegraph companies and is described in another paper. The portion of the transmission system between the regional offices and the head office and the sorting of the information in categories is provided by the Bell Telephone Company and this is the portion of the system described in this paper. The electronic circuitry which performs the sorting operation is described in detail in another paper.

Transmission from Regional Offices to Head Office

At each of the nine regional offices, the data is available in the form of five level perforated paper tape. A No. 14 transmitter distributor accepts the paper tape and transmits the data in the form of electrical pulses over telephone company telegraph facilities to the head office in Toronto at the rate of 75 words per minute. At the head office, each circuit is terminated in a No. 14 receiving only typing reperforator and a No. 28 receiving only page printer.

The No. 14 typing reperforator reproduces the five level perforated paper tape containing the data and also types the data on the tape for identification purposes. The typing reperforators are mounted on drawer type shelves, stacked three in a cabinet. Each drawer also mounts a power-driven tape winder to wind the tape as it is perforated. Each tape winder is equipped with an individual visual and a common audible alarm to indicate when approximately 200 ft. of tape has been wound. This length was decided upon as being a convenient length for sorting. The typing reperforators are also equipped with individual visual "low tape" alarms to indicate when the supply roll of tape to the reperforator has been perforated.

The No. 28 page printer produces a printed page copy of the data being received. This page copy is scanned by an operator to check for transmission errors and is later discarded. By suppressing printing on several characters, a format of blocks of typing separated by blank spaces is obtained, which lends itself to a quick visual check. Each page printer is also equipped to light an individual visual alarm when a "blank" character is received. The "blank" character is not used in the transmission of data and is the character usually introduced by a "hit" or an "open" in transmission path.

Data Sorting Operation

The five level perforated paper tape being produced by each typing reperforator contains data from a number of area offices and one regional office. This data includes several types of information, such as meter readings, pay-roll, stock, etc. For economic reasons, it is desirable that the computor have one type of data programed into it for a given period and so it was decided that the data would be sorted into general categories before the programing operation. The *tape sorter* was designed to meet this requirement. It performs the sorting operation by accepting perforated paper tapes from the typing reperforators, with each tape containing several types of information, and producing several perforated paper tapes, each of which contains only the type or types of information selected by the operator. These output tapes are later converted into magnetic tapes for programing into the computor.

The *tape sorter* sorts the data at a rate of 600 w.p.m. The teletypewriter circuits from the regional offices are transmitting data at a rate of 75 w.p.m. so that a *tape sorter* unit will sort the output of seven or eight circuits without introducing an accumulating delay. Two *tape sorter* units were installed to handle the traffic from the nine regional offices and to provide for growth.

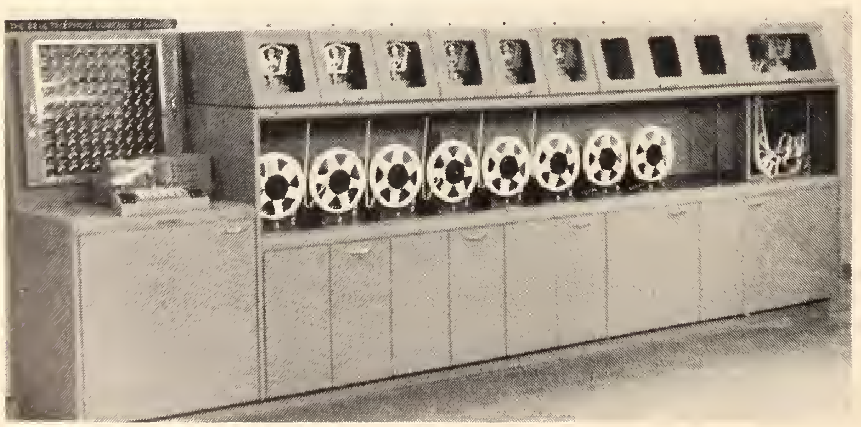
Each *tape sorter* is a self-contained unit mounting a 600 w.p.m. double gate tape reader with two associated tape unwinders, nine 600 w.p.m. tape reperforators or punches with associated high speed tape winders, a tenth 600 w.p.m. tape reperforator with an associated No. 14 transmitter distributor, the electronic control equipment, a control panel of one hundred selector switches and the required power supplies, all in a sheet metal cabinet 14 ft. long, $2\frac{1}{2}$ ft. wide and 5 ft. high. The reperforators are mounted on the top deck of the cabinet and covered with a common hinged cover to reduce noise. The tape winders are mounted on a lower deck under their associated reperforators. The electronic control equipment is mounted in the bottom of the cabinet in a pull-out framework. The tape reader and the control panel of switches are mounted at one end at a suitable height (see Fig. 1).

The input device of the *tape sorter* is the 600 w.p.m. double gate tape reader. The transmission through the *tape sorter* is on a six parallel path basis to accommodate the five level code plus a "control" level. Each path consists of several stages of storage termed "shift registers". As the information is stepped through these "shift registers" in succession, it provides a means of electronically looking at a number of consecutive characters in a message at any given instant. A visual display of the signal in each storage register is provided as a check of operation. The output devices of the *tape sorter* are ten 600 w.p.m. tape reperforators or punches. The sorting is done by automatically selecting the appropriate reperforator to terminate the transmission path through the *tape sorter*.

The *tape sorter* could be built to recognize codes of any number of digits. For this application, it was built to recognize four digit codes which have the first two digits between 00 and 99 and the last two digits assigned to verify the first two. At present, it is equipped to recognize 50 such codes. The codes are assigned by a simple strapping on a terminal board. Space was provided to allow the *tape sorter* to be equipped to recognize 100 codes.

The control panel consists of 100 nine position switches arranged in ten rows of ten for easy locating Each switch corresponds to an

Fig. 1. Tape sorter.



assigned four digit code and the nine positions of each switch correspond to first nine output reperforators. The programing is done by setting each of the "code" switches to a selected reperforator position. By this means, any one or more of the fifty types of messages as identified by an assigned code, can be directed to any one of the first nine output reperforators. Any message not identified by one of the assigned codes is automatically directed to the tenth or "error" reperforator.

The sorting operation is performed by taking a 200 ft. reel of perforated paper tape from one of the typing reperforators which terminate on incoming circuit from a regional office and placing it in one of the two centre unwind tape reels located adjacent to the reader of the *tape sorter*. As the reader is equipped with two input gates, the tape can be loaded into the idle gate and it will be read automatically when the tape being read by the other gate is spent. The spent tape is stored in a bin under the reader. Each message in the tape begins with the characters "Figures D", immediately followed by the four digit code which identifies the type of information contained in the message. Each message ends with at least three "carriage return function" characters. As the reader reads the tape, it steps the information through the shift registers. When the electronic control circuitry recognizes that the last two shift registers contain the "Figures D" combination, it knows that the four preceding shift registers now contain the four digit code identifying the message. It reads the code and connects to the transmission path the output reperforator programed by the control switches to receive messages identified by that particular code. When the electronic control circuitry recognizes that the last three shift registers contain the three "carriage return function" characters indicating the end of the message, it prepares to disconnect this reperforator. Upon receipt of the "Figures D" characters heading the next message, it disconnects this reperforator and connects the appropriate reperforator in accordance with the new code. The reader and each output reperforator is equipped with a Veeder Root type counter to indicate the number of messages that have passed through that unit.

The output tape from each of the first nine reperforators is wound on an associated power driven tape winder which can wind up to approximately 1,000 ft. of tape. Each reperforator is equipped with an audible and visual "low tape" alarm to indicate when its 1,000 ft. supply roll of paper tape has been perforated and rewound on the associated tape winder. The rolls of perforated tape are removed from the tape winders by the operator and are stored in suitably designated film type cans until they are to be read by the "paper tape to magnetic tape" convertor. The messages they contain will then be transferred to magnetic tape which will be programed into the Univac computor.

A power driven tape unwinder is provided which will hold the 1,000 ft. rolls of output tape from the sorter. This allows the output rolls of tape to be rerun through the input reader of the *tape sorter* to facilitate a resorting operation.

The output tape of the tenth or "error" reperforator is fed directly into a No. 14 transmitter distributor and the messages are transmitted automatically at 75 w.p.m. to a No. 28 page printer located at the supervisor's desk for investigation. The spent tape is stored in a bin under the transmitter distributor.

Transmission of Administrative Traffic

Outward transmission of administrative traffic from the head office to a number of the regional offices is being provided by using full-duplex teletypewriter facilities between these points. Full duplex operation permits the transmission of information in two directions simultaneously over the telegraph facility. In this case, administrative traffic can be sent out from the head office to the regional office while data is being sent in from the regional office to the head office on the same facility. At the head office, one gate of a No. 1 multiple gate transmitter distributor is assigned to the outgoing side of each full duplex facility. A No. 1 multiple gate transmitter distributor is a unit equipped with three independent transmitting gates on a common base and driven by a common motor which provides a more economical arrangement than individual No. 14 transmitter distributors when a number of transmitting units are required. At the head office, the administrative messages are prepared in tape form and inserted in the appropriate gate of a multiple gate transmitter. At the regional office, the receiving side of the full duplex facility is terminated in a No. 28 page printer which produces page copy of the message.

Miscellaneous

At the head office, one gate of a multiple gate transmitter is used to send into a room circuit terminated by a No. 14 typing reperforator and a No. 28 page printer. The arrangement is used for tape checking purposes. Additional items of teletypewriter equipment are provided at the sorting centre for maintenance spares and all items of line equipment and facilities appear on a jack panel to facilitate patching and interchange of units. A double-beam oscilloscope and a transistor test set are the only pieces of special test equipment required for maintenance in addition to the usual test meters and teletypewriter maintenance tools.

The Tape Message Sorter

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IN THE FEW years of semiconductor history, development of switching circuits largely has been directed towards high speeds as demanded by the computer designers. The relatively slow speeds of data handling suitable for general industrial uses have not attracted as much attention. Perhaps the tendency is to look for semiconductor applications in fields where up to now large quantities of vacuum tubes have been used. Computers, of course, are in this category.

The tape message sorter is an industrial application of semiconductor logic circuits. It was first developed for the Bell Telephone Company of Canada and installed at the Ontario Hydro Electric Power Commission's computation centre in Toronto. Coded data is received at the centre from the various regional offices on the normal 75 word per minute teletypewriter facilities. Because the computer does not have provision for sorting or categorizing of the data prior to processing, a separate sorting machine was required. Furthermore, since there are several incoming lines the sorting has to take place at a considerably faster speed to keep up with the traffic.

The tape is manually removed from the receiving apparatus, of which there are several, and fed into a tape reader. The reader, operating at 600 words per minute, inserts the coded data intact into the sorter where the messages are identified and directed to one of several reperforators which make new tape. Each reperforator, or punch, can be assigned to accept one or more categories of data. If there are more varieties of messages to be sorted than there are punches available, any punch can be assigned to accept the surplus and the new tape then can be sorted. Since the message identification code is always reproduced on the new tape, any number of resorts is permissible.

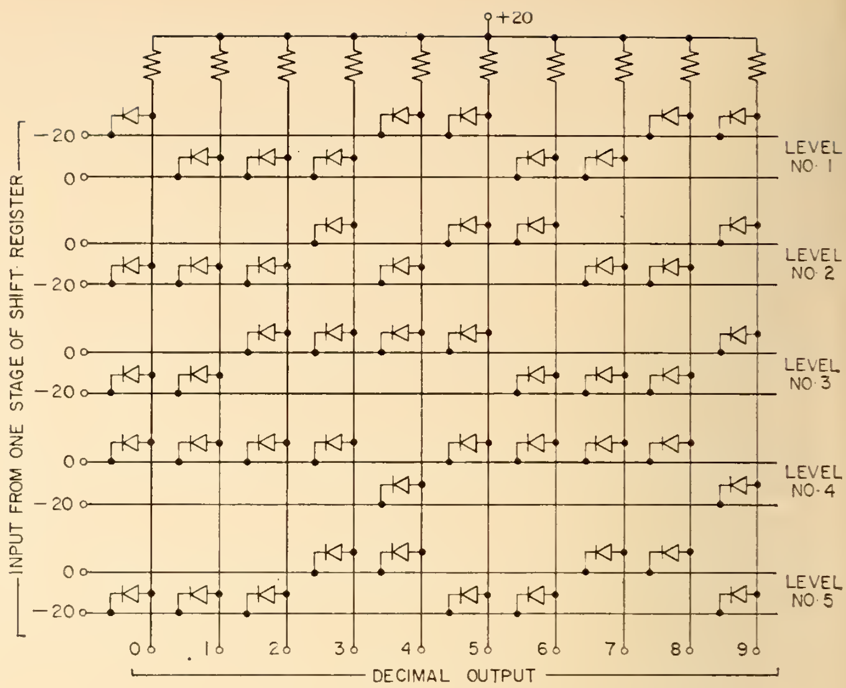
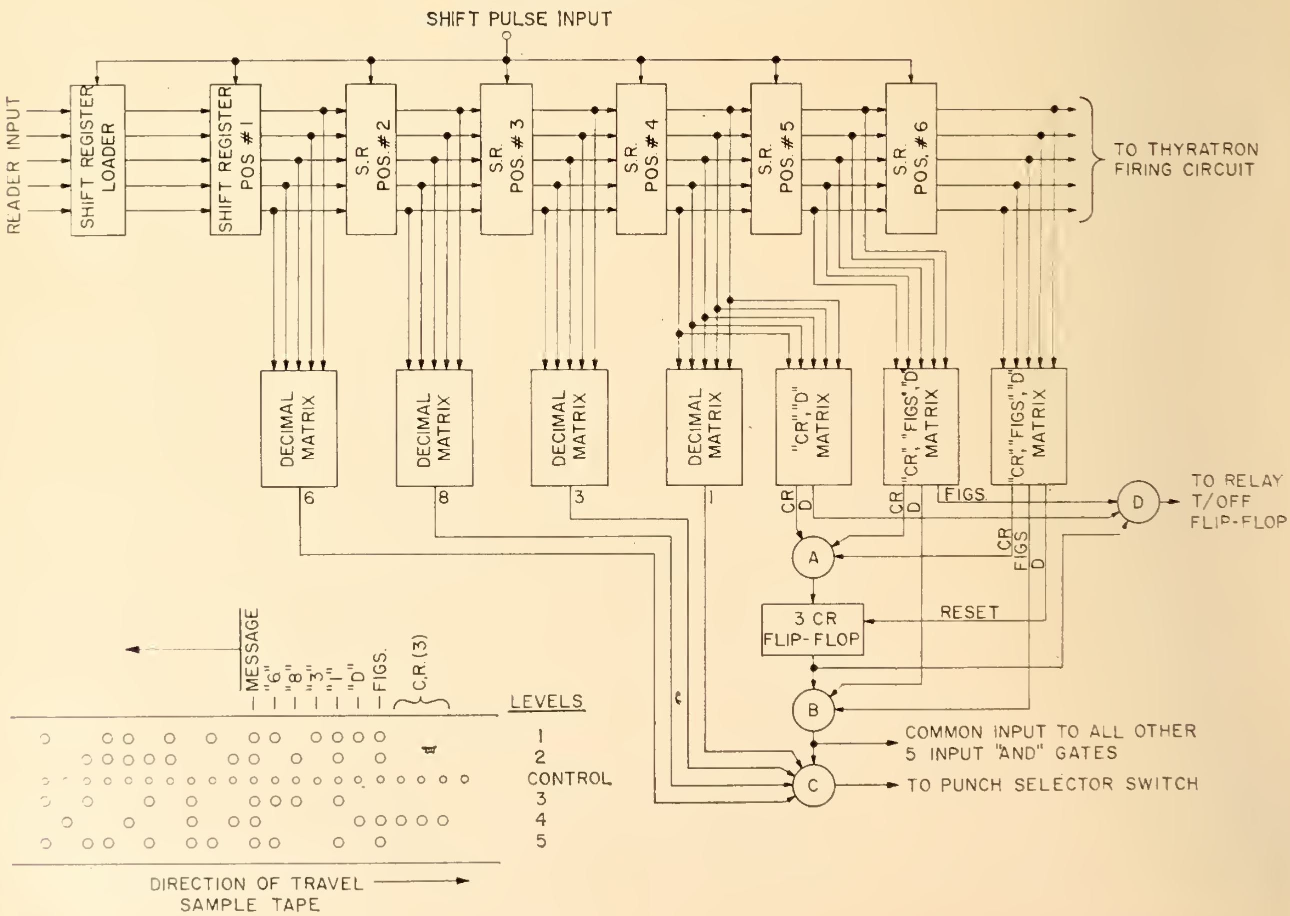


Fig. 1. Diode conversion matrix

Some general problem considerations

Because the six character code by which a message is identified has to be reproduced by the selected reperforator, it is necessary to direct the

Fig. 2. Block diagram of route selection logic



message through a form of delay for a six character duration, so that the appropriate punch can be selected during this delay period prior to read-out.

Since the punches require 120 v. for operation, it was necessary to use relays for punch selection. But because relays require an appreciable portion of the character interval for their operation, an auxiliary storage of one character duration was necessary, which comes into effect only during message switching.

Although facilities for eight reperforators only were required, it was necessary for the circuits to be flexible enough for addition or deletion of reperforators without affecting the general operation of the sorter.

Keeping constant phase relationship among punches is difficult. Mechanical coupling could be provided, but the system would not permit easy exchange of punches or stopping of a given punch while others were running. Therefore, it was required that the readout circuits could be brought under control of any punch, in any order, with any phase relation between reader and punches.

It was necessary that the read-out and all the selecting and switching functions be performed while the tape is being read-in at a constant speed. That is, the tape should not stop during route selection and switching. It was also desirable that the facilities for circuit adjustments be kept to a minimum.

The following sections of the paper describe in some detail the more important circuits and the functions they perform. Space does not permit

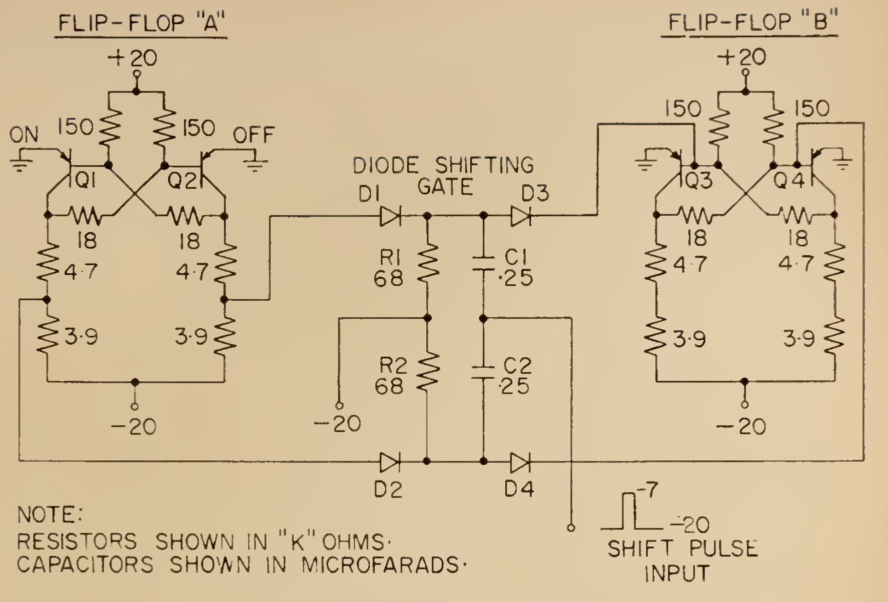


Fig. 3. One state of shift register

a complete description of all circuits, but it is hoped that the coverage given will be sufficient to give the reader some appreciation of the operational philosophy of the tape message sorter.

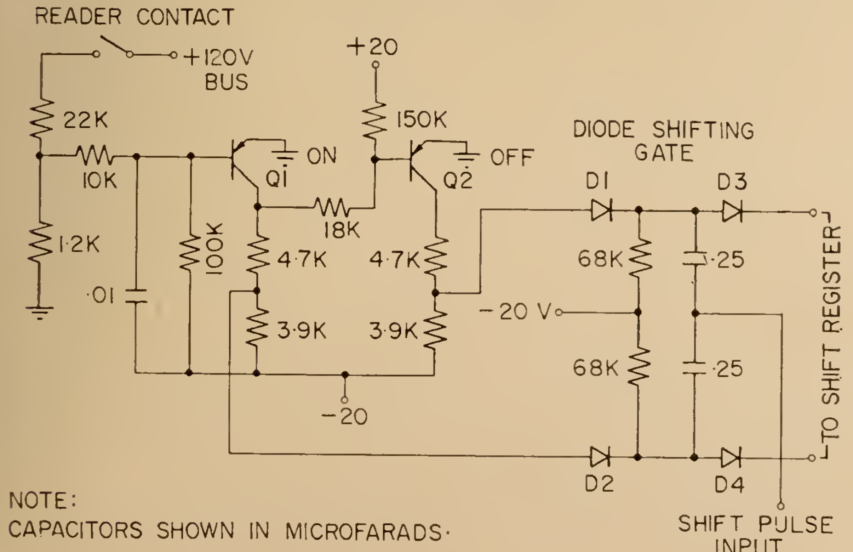
Route selection

The complete message identification code consists of the symbols "Figs" and "D" followed by two numerals which are followed by the 99 complement of the two code numerals, e.g. code number 13 would be "Figs D 1386". Since there is a finite probability of such a combination occurring within the body of the message itself, a further stipulaiton was made that only that code combination would constitute a beginning of a new message that was preceded by at least three carriage return symbols. Furthermore, the carriage return symbols need not be immediately ahead of the identification code group.

Since all information is in the form of the five level teletypewriter code, some method of conversion into decimal was necessary. A simple and reliable form of conversion was achieved with a diode matrix shown in Fig. 1. The five levels of input are provided by the five flip-flops constituting one stage of the shift register. As may be observed in Fig. 1, the flip-flop of level No. 1 is in opposite state to the flip-flops of the other four levels. This is the tape code representation of the numeral "3". It may be observed in the example that bus bars of all the decimal outputs are at -20 volts except bus "3" which is at zero volts. A similar diode matrix was constructed to recognize the symbols "Figs.", "D", and "CR" (carriage return).

In Fig. 2 the flow of information is from the tape reader on the left, through the shift register to the thyratron firing circuit on the right. As may be observed, when a group of three or more "CR" characters go through the shift register, the outputs of the last three matrices will energize the three-input *and* gate "A" which will trigger the 3-CR flip-flop. This flip-flop will provide a steady d-c. input to *and* gate "B". Hence, when the next set of characters "Figs" and "D" are located in shift register positions six and five respectively, the last two matrices will provide the remaining two in-

Fig. 4. Shift register loader



puts to *and* gate "B", the output of which will provide one input to all five-input *and* gates "C". A separate gate "C" is allocated to each identification code. In the example in Fig. 2 only one gate "C" is shown and it is wired into the decimal matrices to recognize numerals 1386. Therefore, when characters "Figs., D, 1, 3, 8, 6" are located in positions 6, 5, 4, 3, 2, 1, respectively of the shift register, *and* gate "C" will produce an output which will trigger the selected relay flip-flop causing that specific tape reperforator (or punch) to be connected to the Thyratron Firing Circuit.

The end of any given message is recognized by the location in positions 5 and 4 of the shift register, the characters "Figs" and "D", respectively of the next succeeding message. These two pulses, plus the output of the 3-CR flip-flop provide the necessary inputs to *and* gate "D", which will then set the relay turn-off flip-flop causing the system to be brought to its initial state in preparation for the new message following.

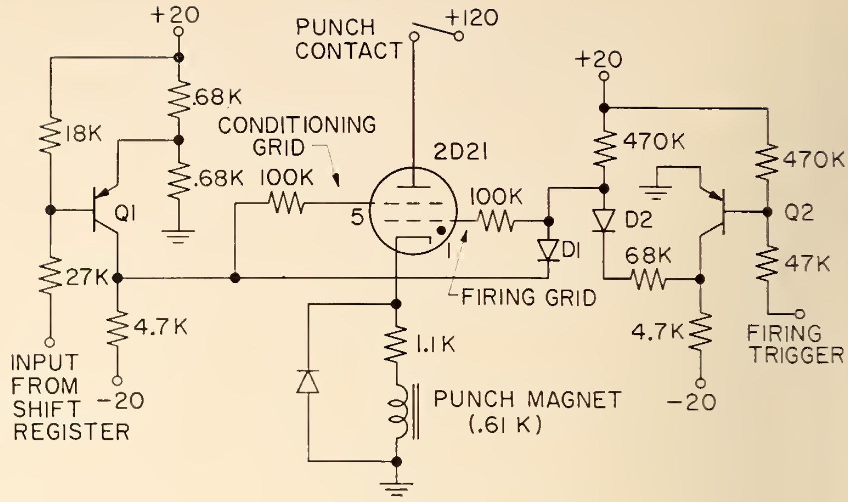


Fig. 5. Thyratron firing circuit

Shift register

As explained previously a delay or temporary storage of six character duration is required so that the complete identification code may be recognized and the appropriate route selected before the message (and the code preceding it) may be read out. A common type of shift register, consisting of five parallel rows of flip-flops, and each row containing six stages, is used to produce the delay. The five rows are required to accommodate the five-level teletypewriter code. Actually, a sixth level is necessary to control the stepping of the tape, but this is satisfactorily accomplished with a single flip-flop (control flip-flop).

A two-stage shift register is shown in Fig. 3. It consists of two flip-flops interconnected by two diode shifting gates. Transistors are driven into saturation when *on* and are cut-off by about two volts when *off*. Let it be assumed that in Fig. 3 transistors Q_1 and Q_4 are *on* and transistors Q_2 and Q_3 are *off*. Capacitor C_1 will charge up through diode D_1 to -17.1 v. and C_2 will charge up to -10.9 v. When the common junction of C_1 and C_2, which normally is at -20 v., receives a shift pulse of about 13 v. amplitude Q_4 will be cut-off by C_2 acting through D_4. Q_3, of course, will be turned *on* by the action of Q_4. Since with the application of the shift pulse the junction of C_1 and D_3 will only rise to -4.1 v., the shift pulse will not interfere with the operation of Q_3. Flip-flop "B" now is in the state that flip-flop "A" was before the application of the shift pulse. The 68K resistors R_1 and R_2 provide a discharge path, for the capacitors, of a somewhat lower resistance than the reverse resistance of diodes D_3 and D_4. Without R_1 and R_2 the leakage currents, through D_3 and D_4 would charge C_1 and C_2 to —2 v. and 0 volts respectively, causing D_1 and D_2 to be biased in reverse direction and thus disabling the shifting operation.

Shift register loader

The transfer of information from the shift register loader into the first stage of the shift register is identical with the interstage transfer. In Fig. 4 a "0" is represented when Q_1 is *on* and Q_2 is *off*. This is the circuit's normal standby state when the reader contact is open. When the reader contact is closed, representing a "1", Q_1 is cut-off and Q_2 turned *on*.

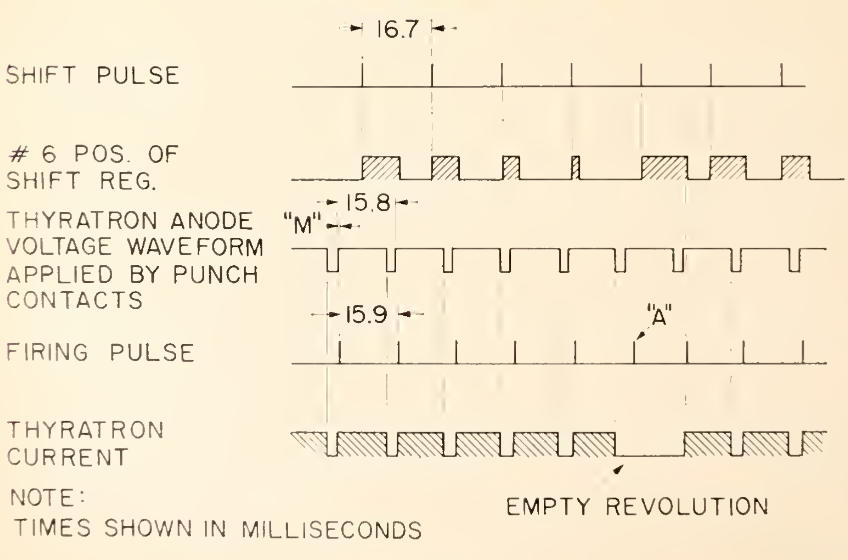
The shift pulse occurs about 4 milliseconds after the contact closure. This interval is necessary to accommodate slight differences in operating synchronism of the other reader contacts, bouncing of contacts, and the charging of the capacitors in the shifting gate. The integrating action of the capacitor in the base of Q_1 serves further to suppress the effects of reader contact bounce.

Thyratron firing circuit

The perforator magnets require 100 ma. at 120 v. for their operation. Since no transistors were yet commercially available that would handle such a load it was necessary to use thyratrons.

Normally thyratrons are fired by vacuum tubes or other thyratrons

Fig. 6. Thyratron operating wave forms



where large signal-voltages are available. In transistor circuits the pulse magnitudes are only about 15 to 20 v., far from sufficient to reliably trigger dual grid thyratrons by employing conventional circuit methods. Fig. 5 shows a circuit arrangement whereby a dual grid type 2D21 thyratron is satisfactorily operated for anode potentials from 115 to 140 v. The improved performance is obtained by using a diode gate in the control grid circuit.

Transistor Q_1 receives its input from the last stage of the shift register. When Q_1 is saturated the collector potential is about +8 v. and when it is cut-off the collector is at about -19 v. The collector of Q_1 provides the conditioning voltage to grid 5 of the thyratron. It may be observed that when this voltage is at -19 the potential of grid 1 (the firing grid) is also at -19 v. because of the location of diode D_1 in the circuit. Therefore, a firing pulse appearing at the collector of Q_2 will have no effect on grid 1 because of the blocking action of diode D_2. However, when the collector of Q_1 is at +8 v., diode D_1 will be reverse biased, allowing grid 1 to remain at about -15 v. Hence, when the firing pulse arrives, Q_2 will be saturated, allowing grid 1 to rise to about +3 v. and causing the thyratron to be ignited.

In the message sorter a set of 6 thyratrons is used, one for each of the 5 character levels, plus one for the control or stepping magnet. A firing pulse is simultaneously applied to the number 1 grid of all six thyratrons, but only those thyratrons will fire that have a conditioning potential on grid 5. The conditioning potentials are determined by the information in the last stage of the shift register. The control thyratron receives a conditioning voltage every

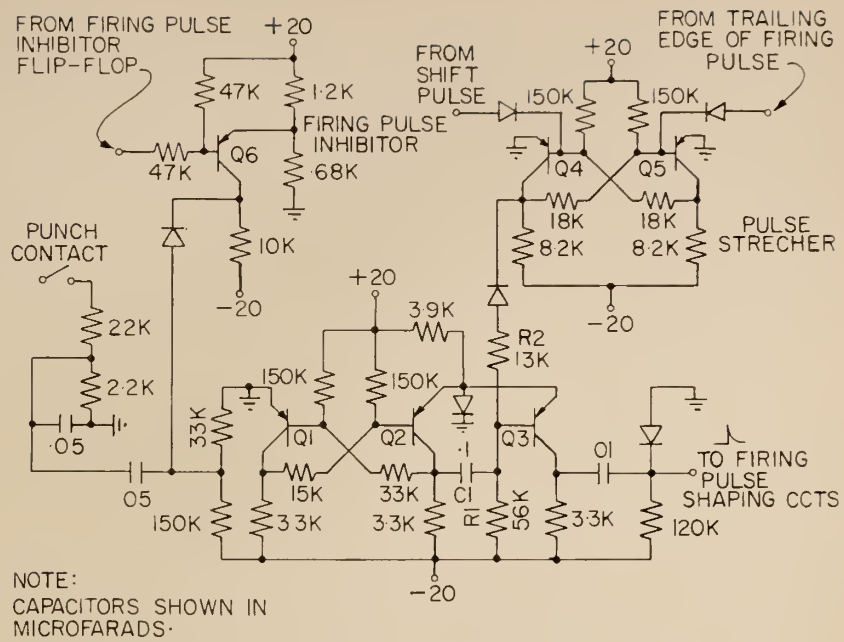
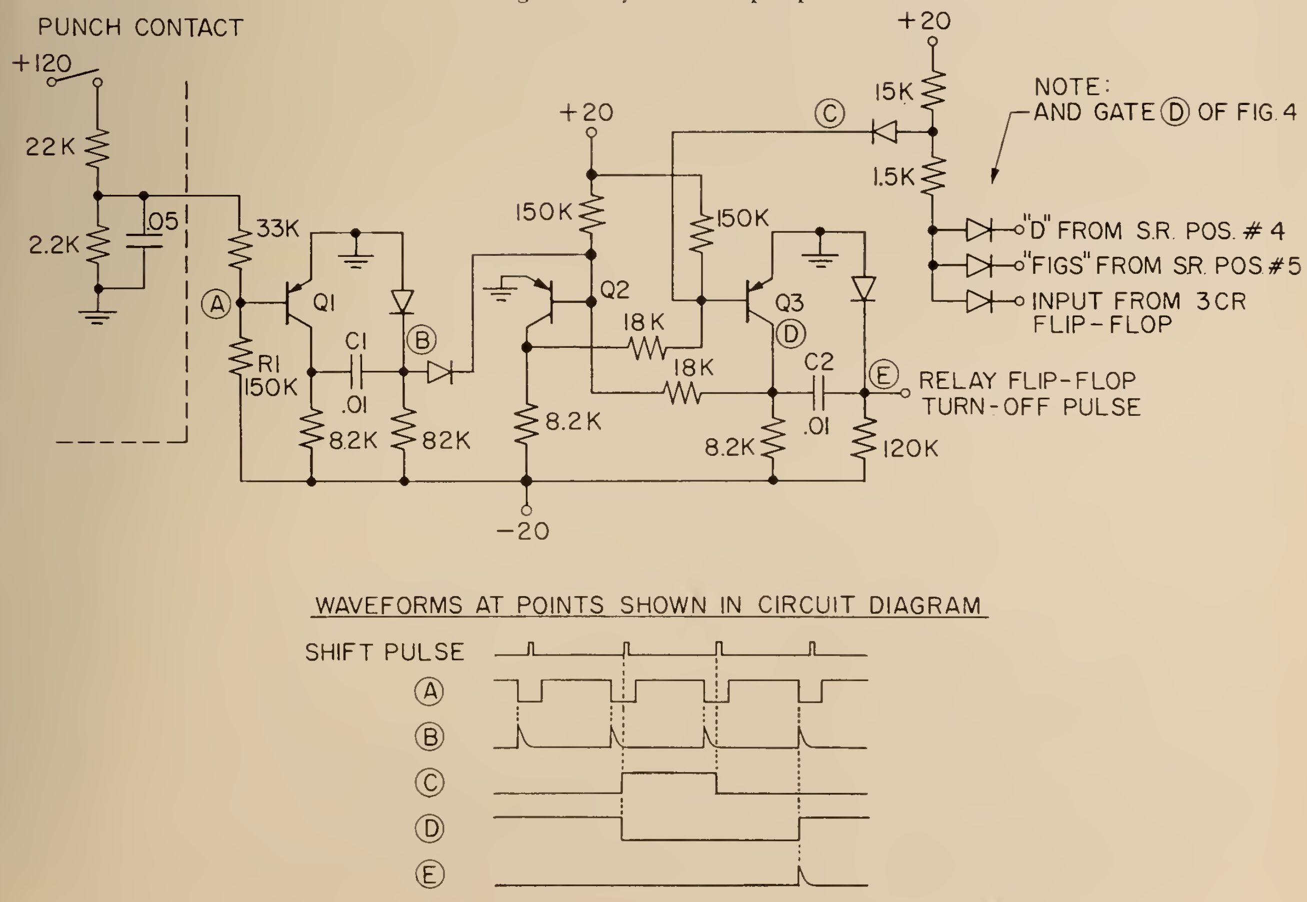


Fig. 7. Firing pulse delay

Fig. 8. Relay turn-off flip-flop.



time the tape reader reads a character, thus permitting the new tape to be stepped along the same number of times as the tape that is being read. The thyratrons are extinguished by the opening of the punch contacts which are in series with the thyratron anodes.

Speed differential of read-in and read-out

Although the tape is read at constant speed by the tape reader, the actual message information to any specific punch comes in at irregular intervals. Even if only one punch were involved, there would still exist the problem of precise synchronization of the punch speed with the reader speed.

The method used in the sorter to overcome this difficulty was to operate the punch at about 5½% higher speed than the reader and arrange for the punch to interrogate the output stage of the shift register and whenever information would be present, the thyratrons would fire and the last stage of the shift register reset to zero. Every eighteen revolutions of the punch mechanism the punch would catch up to the reader, hence no new information would be present for the punch to receive, so the punch would make one empty revolution to waste the accumulated surplus of time.

To perform the control function the time interval ("M" in Fig. 6) between punch contact closure and the thyratron firing is made continuously variable. That is, as the punch is catching up to the reader this time interval is increasing by about 0.1 millisecond per revolution until the time the actual overtake occurs. At that time the punch will make one empty revolution, but the next immediate firing will take place about two milliseconds sooner than it would have occurred if the punch were still behind the reader. This sudden shortening of the time interval "M" ensures that the information is extracted from the last stage of the shift register sufficiently early so that there will be no interference, during overtake, between read-out and read-in. The 2 millisecond shortening of the time interval between the end of the empty revolution and the next thyratron firing is the total accumulated time during the eighteen preceding operations. The timing waveforms are shown in Fig. 6.

The sequence of events as shown in Fig. 6 are as follows: The shift pulse inserts information into No. 6 position of the shift register, which in turn places a potential onto the conditioning grid of the thyratron. Punch contacts close, applying potential onto the thyratron anode, and after an interval of time "M" a firing pulse occurs igniting the thyratron. The trailing edge of the firing pulse erases the sixth position of the shift register leaving it ready for the shift pulse to insert new information. The thyratrons are extinguished by the opening of the punch contacts which remove the anode potential.

It may be observed that when firing pulse "A" occurs, new information has still not arrived into shift register position No. 6, hence the thyratrons will not fire and the punch proceeds to make an empty revolution.

The delay interval "M" between the rising edge of the anode voltage and the firing pulse is produced by a monostable flip-flop which is triggered by the application of the voltage to the anodes. This firing pulse delay flip-flop is shown in Fig. 7. During standby, transistors Q_1 and Q_3 are *on* and Q_2 is *off*. When a rising pulse turns Q_1 *off*, it in turn causes Q_2 to turn *on* which, through capacitor C_1, causes Q_3 to be cut off until the charge on C_1 leaks away through resistor R_1, allowing R_1 to turn Q_3 *on*. The action of Q_3 then turns Q_2 *off* and Q_1 *on*. It can be seen that if Q_4 of the Pulse Stretcher is *on* resistor R_2 will have small effect on the discharge time of C_1. However, if Q_4 is *off*, as when turned off by the leading edge of the shift pulse, R_2 will essentially be paralleling R_1 causing a more rapid discharge of capacitor C_1. This means that the time interval "M" in Fig. 6 will be minimum.

Since the Pulse Stretcher is flipped in one direction by the leading edge of the shift pulse and in the reverse direction by the trailing edge of the firing pulse, the time interval "M" will be longer at each successive cycle of operation because Q_4 will be spending less and less time in its off state.

Auxiliary store switch-over

Due to the flow of messages through the sorter being continuous, i.e. the beginning of a given message immediately follows the last carriage return of the preceding message, precautions had to be taken during switching from one punch to another that no information be lost. As has already been explained, only one set of six thyratrons is used in the sorter and the six magnets of each punch are connected through relay contacts to the thyratron cathodes, one punch at a time. So when a new message arrives, the relay of the punch that was being used has to be de-energized and the relay of the new punch energized. Actually, a turn-off pulse is supplied to all punch relay flip-flops and the code of the new message then selects and energizes the appropriate punch relay flip-flop for the new message. This same turn-off pulse also energizes the error punch relay flip-flop so that should the code of the succeeding message be unrecognizable, it would proceed to the error punch. But if the new code is recognizable and it causes one of the punch relays to be selected, the same turn-on pulse causes the error punch relay flip-flop to be de-energized.

Because the operate time of relays is a substantial percentage of the time interval between the characters of a message, one extra stage of shift register is provided to act as a temporary or auxiliary storage into which the new message will go during the switchover period. When the switchover has been completed, the new punch will extract the information from this auxiliary store, and continue to do so, until the occurrence of the first coincidence between the shift pulse and firing pulse. At the time of this coincidence, there exists an accumulation of two milliseconds of time which normally would result in one empty revolution of the punch (as has been explained earlier), but instead, this first coincidence is used to trigger the switchover circuits back to their normal operating position. That is, the punch will begin to extract information out of the sixth position of the shift register. The two milliseconds of accumulated time provide sufficient time for the switchover to take place and circuits to stabilize for the new or normal mode of operation.

Relay flip-flop turn-off

The relay flip-flop turn-off pulse is required at the conclusion of the last character of the last message or, stated another way, when the characters "Figs." and "D" of a new message are located in positions 5 and 4, respectively, of the shift register. Of course, only that set of "Figs.", "D" must be recognized that has been preceded by a minimum of three carriage returns.

In Fig. 8 Q_2 and Q_3 form a flip-flop with one input being derived from Q_1 and the other input from the *and* gate on the right. This *and* gate is designated as "D" in the flow diagram of Fig. 4. It may be observed that when the punch contact is closed transistor Q_1 is cut-off and capacitor C_1 charges up to 20 v. When the contact opens, waveform (A), resistor R_1 causes Q_1 to saturate causing a positive pulse, waveform (B), to be injected into the base of transistor Q_2. This train of positive pulses keeps the flip-flop turned *on* in one direction until it is set by the output of the 3-input *and* gate which will produce a positive pulse only when the 3-CR flip-flop has been set and "Figs." and "D" are in shift register positions 5 and 4 respectively. Transistor Q_3 will then be turned *off* and Q_2 will be turned *on* causing capacitor C_2 to be charged to 20 volts (waveform D). Therefore, when the next positive pulse of waveform (B) resets the flip-flop (Q_2 to *off* and Q_3 to *on*) a differentiated positive pulse will be produced at (E) as shown on the schematic by the waveform (E). This is the turn-off pulse that is applied to all relay flip-flops simultaneously, causing the error relay to be energized and the other relays de-energized.

Inhibition circuits

Although all punches operate at synchronous speed, the phase relationships of the perforating mechanism are random, and since the electrical contacts on each punch are part of the perforating mechanism, the last character of a given message is extracted on the command of the then operating punch, while the first character of the succeeding message is extracted on the command of the new punch. Because the message information is coming in at a constant speed, it would be possible at times to miss the first character of a new message because a complete cycle of operation was not available when the new punch became connected to the thyratron output.

The electrical contacts on each punch are connected in series with a set of contacts of the respective relays. It is, therefore, impossible to determine whether the first application of the thyratron anode voltage (immediately after switchover) is the result of the closure of the punch contacts or relay contacts.

To make certain that the firing pulse delay circuit is triggered by the closure of the punch contacts only, an inhibit circuit is provided to disable it for a period of time slightly in excess of the time it takes for the relay to become fully operated. The Firing Pulse Inhibitor Circuit is shown in Fig. 7. This circuit receives its input from the Firing Pulse Inhibitor Flip-Flop (not shown) which is triggered into inhibition by the relay flip-flop turn-off pulse and restored by a monostable flip-flop, whose time interval is about two milliseconds longer than the energization time of the relay. This restoring monostable flip-flop is triggered by the output of gate "B" shown in Fig. 2.

A similar arrangement is provided for inhibiting the turn-off pulses from the sixth position of the shift register during the time that a new punch is extracting information out of the auxiliary store. The restoration of this circuit is initiated by the coincidence of the firing pulse and the shift pulse.

Conclusions

A disadvantage of transistors in equipment where mechanical contacts are used for current interruption is the accidental triggering of flip-flops by transients. Precautions have to be taken for ensuring good ground connections and suitable isolation of noise-producing circuits. In tube circuits the operating voltages are several times those in transistor circuits, hence larger transients can be tolerated. It was for this reason that it was necessary to design a monostable flip-flop with a positive standby state similar to a bistable flip-flop.

It may be observed that the manner in which the data was handled is quite general. This means that although the present circuitry is handling five-level teletypewriter data, it can easily be expanded or compressed to handle other forms of binary coded data. The present sorter recognizes six-character message identification codes. This, too, can very easily be changed. For example, because the route selection is performed without interruption in the incoming messages, the sorter can be directly applied to perform automatic routing of digital data in a switching centre.

The power consumption of the electronic portion of the sorter is quite modest. Except for the six thyratrons, dissipating an average of 37 w., the rest of the circuits, which contain over 250 transistors and over 1000 diodes, dissipate 27 w.

Because of the low voltages required by the transistor circuits it was very practicable to use all semiconductor power supplies and regulators. Hence, no provision for circuit adjustments was necessary and reliable operation was achieved for a-c. line fluctuations between 105 and 125 v.

Acknowledgements

During the early design considerations the author was fortunate to have had a profitable technical discussion with Messrs. C. D. Florida and P. M. Thompson of the Defence Research Board, Ottawa.

The author is grateful to the Bell Telephone Company of Canada for permission to publish.

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Communications Between HEPC of Ontario Area Offices and Regional Offices Using the Autoscan System

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Canadian National Telegraphs Engineering Department

THE PRIMARY data gathering networks of the Ontario Hydro's Data Processing Communications Network are provided by the Canadian National Telegraphs. These networks connect one hundred area offices to their associated regional offices, of which there are nine.

Each area office is equipped with

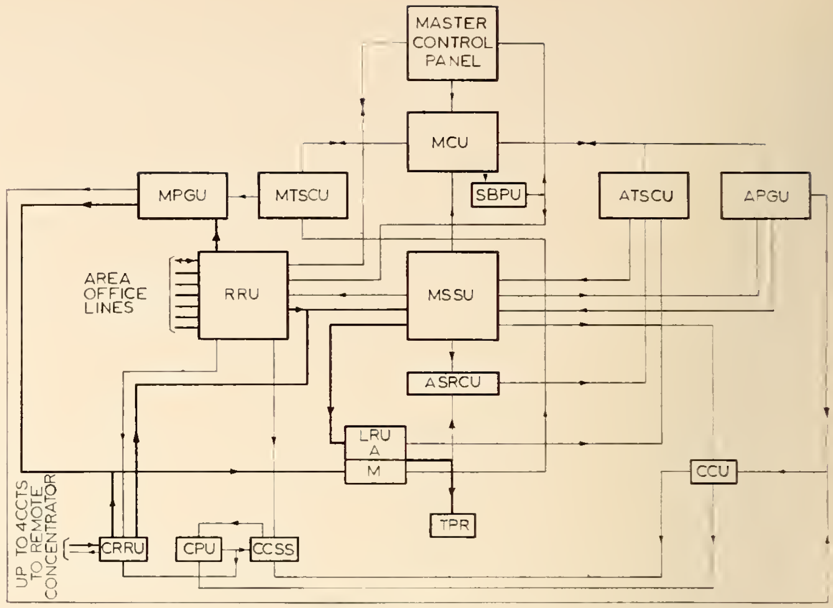


Fig. 1. Block diagram of the Autoscan System.

a Model 14 Transmitter-Distributor which transmits 5 unit tapes at a speed of 60 w.p.m. to the regional offices. In addition a Transmitter Control Unit is provided at each location which is controlled by pulses transmitted from the regional office. Figs. 6 and 7 illustrate the equipment provided at area office locations.

The regional offices are equipped, in general, with two teleprinter machines each equipped with a transmitter distributor and a reperforator attachment. These machines can be used for on-line or off-line operation. When used on-line the reperforator punches a tape and the teleprinter monitors the transmission and prepares page copy.

To facilitate the gathering of data from a large number of offices automatic area office selection by the regional office was desirable. This lead to the development of a selector system which provides considerable flexibility of operation called *Autoscan*. In general each Regional Office is equipped with an *Autoscan* selector.

Autoscan can be operated in two main modes; automatic sequential scanning, and manual. The circuitry of these modes of operation are essentially independent and can be so arranged. However, for ease in operation they are interconnected by control circuitry which enables *Autoscan* to be preconditioned at any time to change its mode of operation without interfering with traffic being received. This results in a saving of operator's time since there is no need to hover over the equipment waiting for the correct time to operate a control.

When automatic sequential scanning is employed a step switch steps to positions to which lines of the area offices are connected. When the step switch steps to a line a start pulse is transmitted to the area office and, if tape has been placed in the transmitter, transmission commences. A traffic sensing unit upon detecting idle line conditions causes the step switch to step to the next line position. There are various stepping rates of the step switch which are described later.

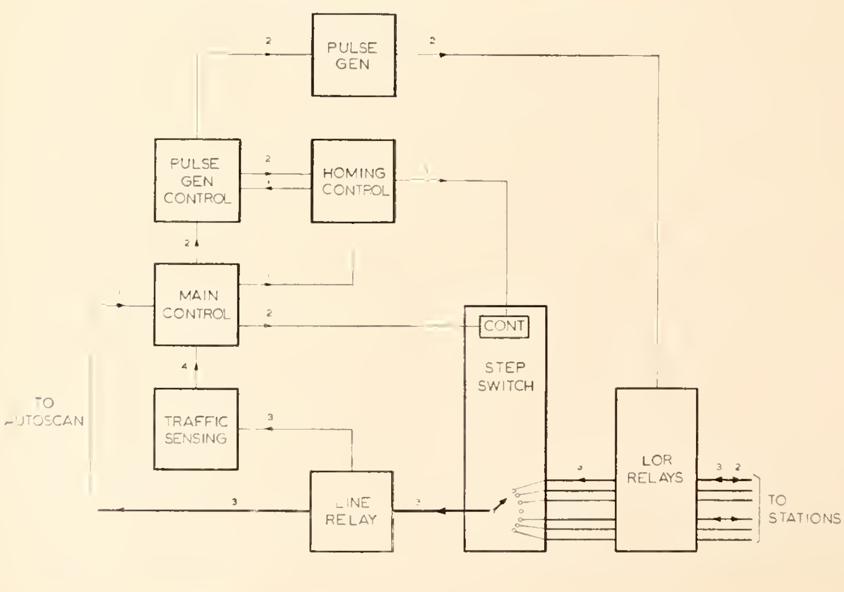
A very useful feature of *Autoscan* is its automatic-manual operation. The name of the operation appears to be contradictory, however this feature permits Autoscan to be manually conditioned at any time to select a station out of the automatic sequence and then automatically revert to automatic sequential scanning when traffic from this station has ceased. The desired station will not be selected by *Autoscan* until traffic, being received at the time the equipment was conditioned to select the desired station, ceases.

In the manual mode of operation, stations are selected by the momentary operation of a station button.

Priority may be given to a station. If the transmission of a particular station is required without delay the equipment is conditioned to select the desired station and the stop button is operated. This operation causes the remote transmitter to be stopped. *Autoscan* then immediately selects the desired station and its transmission is received. This feature is necessary since some station transmissions may be very lengthy.

A special feature required by the Ontario Hydro was a blank character detection circuit. Blank characters are not normally inserted in tapes prepared by the area offices and must not be present in tapes transmitted to the computer centre. The teleprinter is equipped to space on reception of a blank character. This feature is provided so that blank characters can be detected in the monitor copy. In addition the teleprinter is equipped with a set of contacts which

Fig. 2. Block diagram of the Autoscan Concentrator.



close when a blank character is received.

These contacts are wired to the *Autoscan* unit which transmits a stop pulse to the remote transmitter when they operate. The remote transmitter is then stopped and an indicator lamp and audible alarm indicates the situation to the regional office operator who then follows a prescribed procedure. In the meantime, however, the *Autoscan* selects the next station.

Autoscan provides complete indication of the mode of operation and the station being selected or transmitting. Push buttons are employed extensively which have internal illumination for indication purposes. Two types of lamp operation are employed, flashing and steady illumination. The flashing lamp indicates the station which *Autoscan* has been manually conditioned to select, while traffic is being received from a sequentially selected station whose lamp is steadily illuminated. Upon completion of this traffic the lamp of the station is extinguished and the manually selected station lamp then ceases flashing and is steadily illuminated.

Due to the fact that the Area Offices are well dispersed "party-line" operation of stations is not practical. This factor permitted the use of relatively simple control equipment at the area offices and necessitated the development of the *Autoscan* concentrator.

In certain locations it was possible to extend the lines of several area offices to a central point which was equipped with an *Autoscan* concentrator.

A full-duplex telegraph facility connects the *Autoscan* concentrator to the *Autoscan* in the regional office. This results in considerable economy of telegraph facilities for without the *Autoscan* concentrator one telegraph facility per area office would be required between these locations.

Autoscan

Twenty-four stations can be connected to the *Autoscan* Selector equipment either directly or by means of *Autoscan* Concentrators. Provision is made for operation to four *Autoscan* Concentrators.

Autoscan is composed of two main assemblies. A sloping front control panel is situated on top of a cabinet assembly.

Control Panel

Push buttons having internal indicating lamps are used extensively.

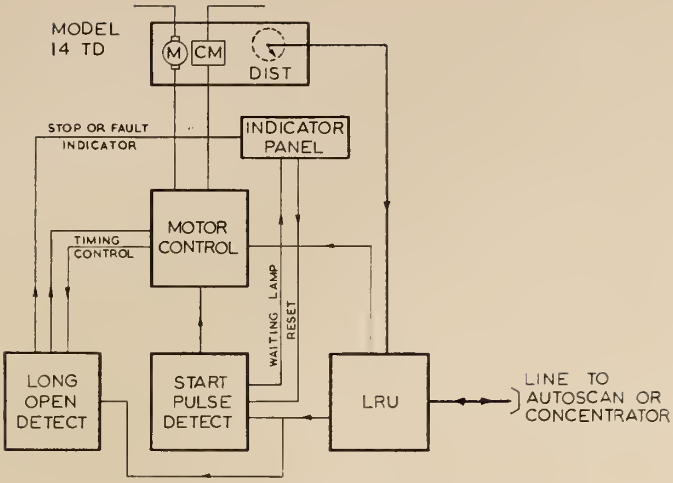


Fig. 3. Block diagram of the Station Equipment.

The following control buttons are provided:

Designation	Indication	Operation
automatic	green	momentary
manual	red	1. momentary — automatic manual 2. lock-in — manual
send stop	blue	momentary
alarm cut-off	white	1. momentary-release audible alarm 2. lock-in-prevent audible alarm
area office	amber	momentary operation

Cabinet Assembly

The circuitry of the *Autoscan* is housed in a cabinet below the control panel. This cabinet has doors on the front and back for accessibility to all parts. Fig. 4 shows the interior of the cabinet as viewed from the front.

For ease of maintenance and production plug-in sub-assemblies are employed extensively. Three shelves in the cabinet mount 13 plug-in units. A four shelf mounts components such as the battery distribution panel, capacitor bank and line resistor bank.

The following sub-assemblies are employed:

1.	Master control unit	MCU
2.	Relay register unit	RRU
3.	Master step switch unit	MSSU
4.	Line relay unit	LRU
5.	Automatic traffic sensing & control unit	ATSCU
6.	Automatic pulse generating unit	APGU
7.	Automatic step rate control unit	ASRCU
8.	Concentrator relay resister unit	CRRU
9.	Concentrator control unit	CCU
10.	Concentrator pulsing unit	CPU
11.	Concentrator control step switch unit	CCSSU
12.	Manual traffic sensing & control unit	MTSCU
13.	Manual pulse generating unit	MPGU
14.	Signal battery pulsing unit	SBPU

Switches are also provided on the control panel to apply a-c. to the rectifiers and teleprinter motors, and for teleprinter selection for on-line use. When one of the two teleprinters provided at the regional office is selected for on-line operation the other is terminated for off-line operation.

The following sub-assemblies are identical: automatic and manual traffice sensing & control units; automatic and manual pulse generating units; signal battery and concentrator pulsing units.

All relays in *Autoscan* are plug-in types. With the exception of the line relays, which are standard type 255A relays, the relay windings have a resistance of 10,000 ohms and are operated by a 7.5 ma current.

Trigger tubes, type 5823, are used for timing circuits. The voltage supply used for their igniter circuits is regulated to ensure stability of operation.

Three standard rectifiers supply power to the *Autoscan* and the two teleprinter machines. One of these rectifiers supplies 120 v. for step switch operation. The other rectifiers supply ± 75 v. to *Autoscan* and also supply power to the teleprinter.

Autoscan Operation

A detailed description of the operation of *Autoscan* circuitry would be very lengthy. This paper will therefore provide a simplified description of the operation.

A block diagram of the circuitry of the *Autoscan* selector is shown in Fig. 1.

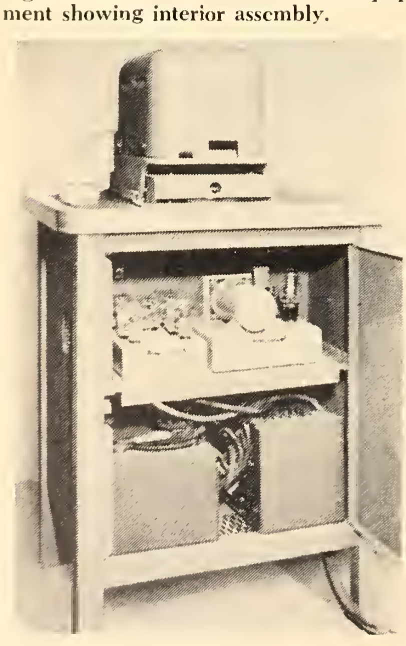
Sequential Scanning

After applying power to the *Autoscan* and teleprinter selected for receiving transmissions from the area offices, the momentary operation of the automatic button on the control panel conditions the *Autoscan* for sequential operation. The mode of operation is indicated by the illumination of this button.

The master step switch (MSS) in the *Autoscan* then commences to scan the lines of the stations connected to it under control of the automatic traffic sensing & control unit (ATSCU).

The lines of the stations are maintained closed when they are in the idle condition. When the MSS steps to a line of a station, the station's push button on the control panel is illuminated. The automatic pulse

Fig. 5. Rear view of area office equipment showing interior assembly.



generator unit (APGU) sends a one second start pulse to the remote station by operating the LTR relay associated with the line in the relay register.

If tape has been placed in the transmitter at the remote station its transmitter control unit (TCU) is conditioned to recognize the start pulse. When it is detected the TCU energizes the motor and clutch magnet of the transmitter and transmission of the tape commences.

The line relay in the *Autoscan* unit repeats the signals received from the station to the teleprinter machine, the ATSCU and also to the automatic step rate control unit (ASRCU).

Master Step Switch Stepping Rates

There are four stepping rates of the MSS.

Five Second Rate

The MSS steps one step every five seconds over closed lines provided that it has not passed its home position twice without receiving traffic.

When the MSS steps to a line a one second start pulse is transmitted. The ATSCU then causes the MSS to step after four seconds of idle line condition.

Two Second Rate

If the MSS steps to a position of an open line the ATSCU steps the MSS to the next line one second after the one second start pulse is transmitted.

Thirty Second Rate

If no traffic is received from stations connected to *Autoscan* for one complete rotation of the MSS from home position to home position the ATSCU is conditioned by the automatic step rate control unit (ASRCU) to step the MSS at thirty second intervals.

However once traffic is received from a station *Autoscan* immediately reverts to its 5 second stepping rate.

Fast Stepping Rate

The MSS steps over unassigned positions at its natural rate under control of its interrupter contacts.

Selection of Concentrated Offices

Autoscan is equipped for operation to four concentrators. The selection of a line to a particular concentrator is accomplished by the concentrator relay register under control of an LTR relay of the relay register which can be operated by either the MSS when sequential scanning of stations is used or by an RR relay of the

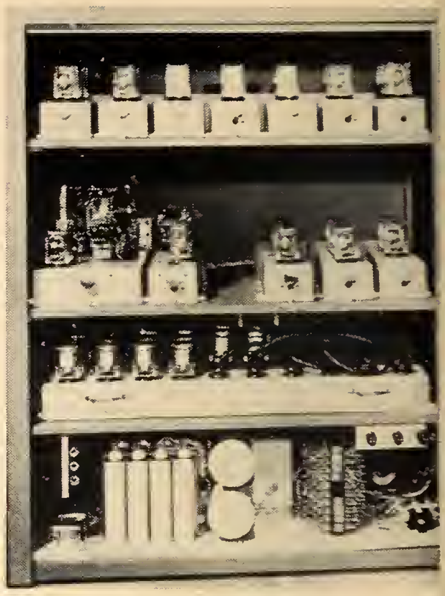


Fig. 4. Autoscan selector: interior assembly.

relay register which is controlled by the station push button when manual station selection is employed.

The LTR Relay of the Relay Register

1. Operates a relay in the concentrator control step switch.
2. Marks the concentrator control step switch.
3. Operates a relay in the concentrator relay register which connects the full-duplex circuit to the concentrator of the office being selected to the transmitting and receiving circuitry of *Autoscan*.

When the concentrator control step switch arrives at its home position a signal is transmitted to the remote concentrator which causes its step switch to be homed.

Pulses from the concentrator pulsing unit step the concentrator control step switch to the position marked by the LTR relay of the relay register. These pulses are also transmitted to the concentrator and they drive the concentrator step switch to the same position as the concentrator control step switch of the *Autoscan* unit.

The lines of the stations connected to the concentrator are connected to the concentrator step switch. When the concentrator step switch comes to rest on a line the pulse generator of the concentrator transmits a start pulse to the station.

After a period as described in "Master Step Switch Stepping Rates" the master step switch steps to the next position.

Automatic-Manual Station Selection

When *Autoscan* is in the automatic

mode of operation provision is made to condition *Autoscan* to select a desired station out of sequence. This is called automatic-manual selection.

To condition the equipment to select a station out of automatic sequence the manual button is momentarily operated. This operation causes the master control unit to apply pulsing signal battery to the manual button lamp, and extinguish the automatic button lamp.

The desired station's button is then momentarily operated. This causes the RR relay associated with the station button, in the relay register to operate. This relay applies the pulsing signal battery to the lamp of the station button.

When the ATSCU detects that traffic, being received while the above operations were performed, has ceased, it causes the master control unit to transfer control to the manual traffic sensing & control unit and the manual pulse generator unit.

In the case of directly connected station circuits the MCU also applies battery to the LTR relay of the relay register which transfers the station line from the MSS to the manual line relay via the manual pulse generator unit. Contacts of the MPGU transmit the one second start pulse to the remote station.

If the station selected manually is a concentrated station the LTR relay performs the functions outlined in the description "Selection of Concentrated Offices" however the receive line of the full-duplex circuit to the concentrator is transferred from the MSS to the manual line relay by the operation of a relay in the concentrator relay register.

The indicator lamp of the manually selected station ceases flashing when the station is selected and is steadily illuminated.

When traffic from this station is completed the MTSCU causes the MCU to revert the system to sequential station selection commencing with the station that would have been selected if the sequential pattern had not been interrupted. The manual button lamp is extinguished and the automatic button lamp is illuminated indicating the change.

Manual Station Selection

When fully manual station selection is desired the manual button is pushed and locked in this state by turning it. This prevents the MTSCU from restoring the system to its automatic mode of operation.

Upon completion of current traffic the system will be conditioned for manual selection of offices.

This mode of operation permits the selection of a single station at one time.

Stop Feature

Traffic received from individual offices on a data circuit can be quite lengthy. If an error is detected in the transmission from a station which would necessitate the tape to be corrected and retransmitted the regional office operator can stop the remote transmitter by the operation of the stop button. This can save considerable time. The *Autoscan* will then select the next station in the sequence.

If an operator wishes to give immediate priority to a station, the station is manually selected and the stop button is operated which causes the remote transmitter to be stopped and the transmission of the desired station will commence without delay.

The operation of the stop button causes either the manual or automatic pulse generators to transmit a one second stop pulse to the transmitting station. Upon detection of this pulse the transmitter control unit at the station causes the motor of the transmitter to be stopped and an indicator lamp is illuminated.

The tape is then corrected, if necessary, and replaced in the transmitter. The operation of the Reset button reconditions the transmitter control unit to detect a start pulse. A waiting lamp indicates that the TCU is thus conditioned.

Autoscan Concentrator

The *Autoscan* concentrator consists essentially of eight control circuits as are indicated in Fig. 2.

The step switch is always homed prior to station selection to ensure that it is in step with the concentrator control step switch of the *Autoscan* unit.

It is driven by the pulses generated by the concentrator pulsing unit of the *Autoscan* unit.

When it comes to rest on a line position the pulse generator of the concentrator transmits a start pulse to remote station.

The traffic sensing unit of the concentrator prevents the stepping of the step switch during transmission from a station.

If a stop pulse is received from the control office the pulse generator of the concentrator transmits a one second stop pulse to the transmitting station causing its transmitter to be stopped. The step switch will not step however since it is disabled by the traffic sensing circuit.

If the circuit between the control station and the concentrator is lost during transmission the transmitting station is stopped in the same manner.

Station Equipment

Each station is equipped with a model 14 transmitter-distributor which is mounted on a table. On shelves in this table are mounted a line relay unit, a transmitter control unit, and rectifiers. The equipment arrangement is illustrated in Fig. 5. Fig. 3 is a block diagram of the circuitry.

In the idle state loop current is maintained. Power is applied to the transmitter control unit (TCU) when tape is placed in the transmitter via its tape sensing pin. The waiting lamp on the table is then illuminated indicating that the circuitry is conditioned to detect a start pulse.

The TCU detects various open circuit conditions. In the idle state a pulse less than 0.75 seconds has no effect, however, a pulse of 0.75 to 1.25 seconds causes the TCU to start the motor of the transmitter and after a slight delay operate its clutch magnet. The tape is then transmitted to the control station.

Prior to transmission, a pulse longer than 1.25 seconds causes a fault lamp to be operated. Transmission will not take place if this occurs. A reset button is provided which when operated restores the TCU to its waiting condition. If the line is open the fault lamp will again be illuminated. The operator must then follow prescribed procedures to have the condition rectified.

During transmission the TCU will detect an open circuit condition which exceeds 0.75 seconds. When this occurs the transmitter is stopped and the fault lamp is illuminated. If this condition is caused by the reception of a stop pulse the operation of the reset button will restore the TCU to its waiting condition which is indicated by the waiting lamp.

If the transmitter has been stopped due to the reception of a stop pulse it may be due to either the control station detecting errors in the tape or due to the control station giving priority to another station. Operational procedures are necessary to clarify the situation.

Comments

The *Autoscan* system was designed

(Continued on page 65)

A LARGE CAPACITY OXYGEN PLANT FOR COPPER REFINING

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This paper describes in detail the largest tonnage oxygen plant in the British Commonwealth, a 330 ton per day unit built for the INTERNATIONAL NICKEL COMPANY OF CANADA, at Copper Cliff, Ontario. The reasons for erecting a unit of this size are considered briefly. Factors governing the design of the equipment and the choice of a cycle for the low temperature process are discussed at length, also the importance of low power consumption and long continuous operation. The process is discussed completely with respect to operating temperatures and product analyses. An engineering flow sheet is included. Mention is made of some of the design difficulties and the solutions adopted. Operating problems, techniques and plant control are covered. The paper is illustrated with photographs of the unit and some of the pieces of equipment which comprise a tonnage oxygen plant.

THE AUTOGENOUS flash smelting of sulphide ore has been considered in much detail for the past sixty years. As early as 1897 Bridgeman proposed a reverberatory furnace in which the sulphide ore would be smelted using the heat generated from the combustion of the ore itself[1]. It had been proposed by Norman[2] and others that oxygen could be used for autogenous flash smelting of copper and copper nickel concentrates and in 1945 the International Nickel Co. of Canada started miniplant tests. The success of these tests, the fact that low cost tonnage oxygen plants were now a commercial possibility and the good prospects for marketing sulphur, led Inco to start pilot plant tests using oxygen at 95-99% from a small 5-ton per day oxygen plant. The pilot plant was operated for two years and confirmed the economies of the oxygen flash smelting process[3]. From the pilot plant studies Inco developed the basic specifications for the oxygen plant which were a minimum capacity of 300 tons per day of pure oxygen delivered at a minimum purity of 95% and at a pressure of 25 per sq. in. gal. The overall power consumption was not to exceed 370 Kw./ton, excluding oxygen compression, and the plant must be able to run continuously for at least 12 months.

Oxygen Plant

At the time that INCO decided to go ahead on full scale operations there was only one tonnage oxygen plant in operation with a capacity equal to their requirements and two plants of larger size were under construction. Several plants had been built in Europe prior to and during World War II but all were under 100 tons day capacity, few produced oxygen at 95% purity and none ran continuously for periods longer than 8 months. The power consumption figures on existing plants indicated a wide variation, with no clearly defined basis for the figures.

Low power consumption was the major factor affecting the process design. Fortunately a plant of about one third the capacity of Inco's was being built by Air Liquide for the Dutch State Mines in Holland, which also had to meet this requirement and it was decided to use a somewhat similar process for the low temperature equipment on the Inco plant. However in scaling up the plant by a factor of three, many design problems occurred which necessitated some new approaches and resulted in what were, at that time, some radical solutions. Another factor which affected design was the decision to use as much automatic and remote control operation as possible to reduce manpower requirements. Up to this time all air separation plants, large and small, were entirely hand operated with the exception of the regenerator reversing valves.

Description of Cycle

A great deal has been published over the past ten years on tonnage oxygen plants, their advantages, basic principles of operation and the use of the *Frankl* regenerator in low temperature separations. The process design adopted for the Inco plant has some unique features which are not present in any other tonnage oxygen plant at present in operation and some pieces of equipment whose successful operation led to their continued use in more than a dozen tonnage plants built since.

The simplified flow sheet of this plant operating on the Oxyton cycle is shown in Fig. 1. In view of the previously published detail it is proposed to confine the description to those parts of the plant which are of process interest and were new developments in low temperature separation. The rest of the cycle will be dealt with only insofar as it forms part of the overall plant.

The plant consists of five main groups; the air compression and purification group, the regenerator section consisting of a pair of nitrogen regenerators and a pair of oxygen regenerators, an auxiliary circuit, the distillation columns with associated coolers and the expansion turbines.

The total air requirements for the plant are drawn into the air intake located at the top of the building and an air filter, and compressed in a two-stage Ingersol Rand centrifugal compressor. (Fig. 2). The compressor is driven by a 6000 hp. Synchronous Motor through a speed increasing gear. The air is cooled in a water wash tower. Due to the frequent high SO_2 concentration in the air around the plant two towers were provided on the original design in case of excessive corrosion developing. This has not proved to be a problem so the second tower has become a large separator. A shell and tube aftercooler is also provided in parallel and can be used during initial start-up and during defrosting operations when it is desirable to have a lower moisture content in the air.

The air, now at a pressure of 70 lb.

per sq. in. gal., is divided into two streams, 94% of the volume going to the regenerators and 6% to the booster compressor. The smaller portion of air, termed the auxiliary cycle, is further compressed to 160 lb. per sq. in. gal., scrubbed with 10% caustic solution to remove CO_2, dried in a desiccation battery and admitted to one of a pair of reversing warm exchangers. This stream is cooled to -105° F. by flowing counter current to a stream of waste nitrogen, passed through a final desiccation over silica gel and liquefied in a second exchanger. This exchanger or liquefier serves also as the reheater for the stream of high pressure nitrogen used in the turbo expanders. The liquefied air is flashed to the high pressure distillation column.

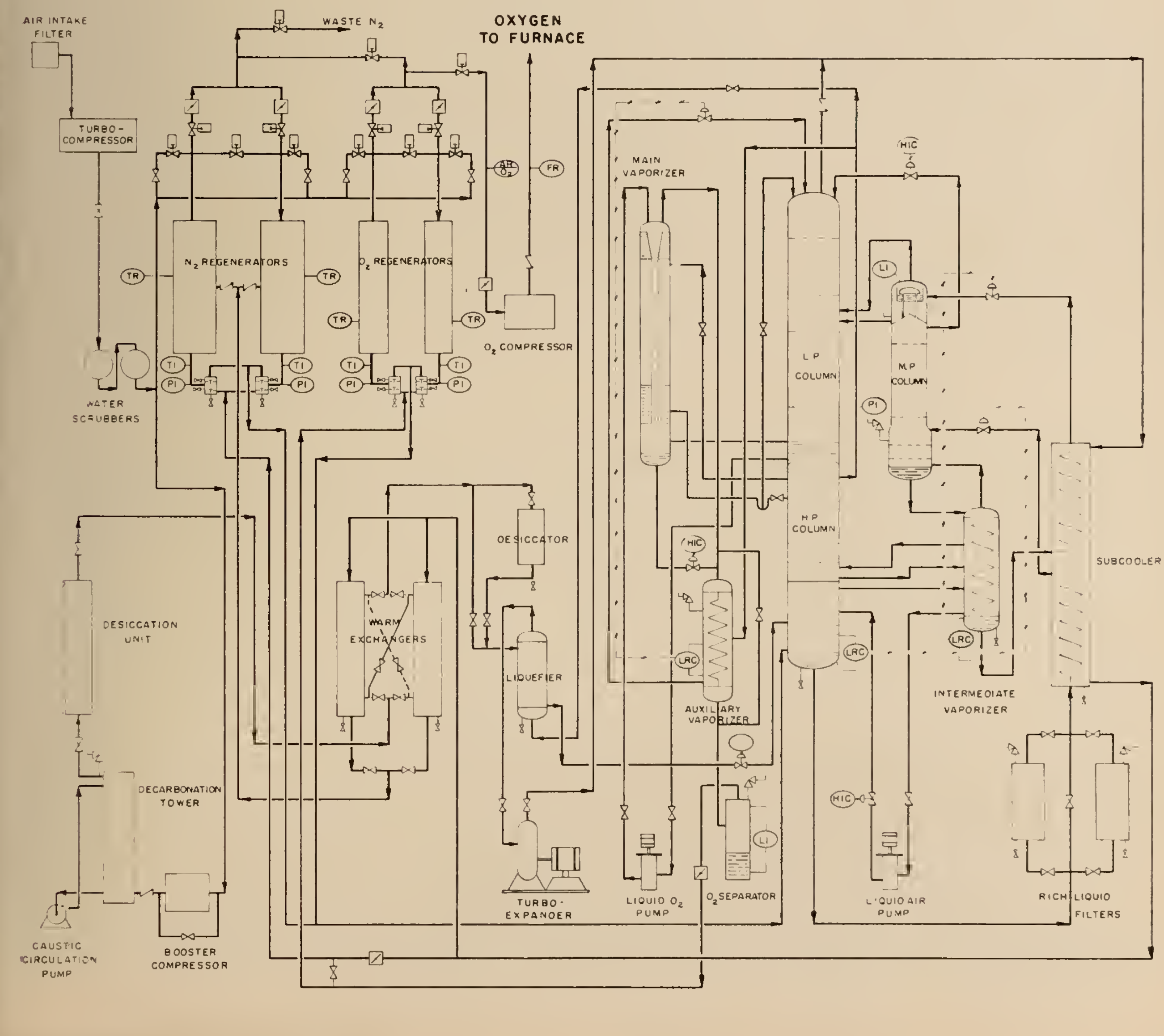
Regenerators

While the regenerators have been discussed previously, some new details of construction should be mentioned. In order to meet the A.S.M.E. Code for low temperature operation, carbon steel could not be used. There remained stainless steel or the new 8% nickel steel developed by Inco for this application. Based on economic reasons the latter material was chosen. Due to the size, fabrication of the 9 ft. diameter aluminum pancakes for the nitrogen regenerators presented some problems and special procedures were used to fasten the successive windings of crimped ribbon. In designing the spacers between pancakes consideration had to be given to the effect of one pancake piled on top of another and the whole subject to flexure on the outer edge due to the reversal of flow and the tendency to droop under their own weight. If not carefully installed the outer winding would tear off at an ever increasing rate and eventually no upper pancakes would be left. A specially shaped hold-down spider is placed on top of the last pancake. It is tightened by jack screws in the dome of the regenerator. These jack screws have to be tightened at successive intervals during the first few months of operation.

The main stream is cooled by direct contact with the precooled aluminum packing in one nitrogen and one oxygen regenerator—at the same time the packing in the other pair is being cooled by the separated products. The streams are reversed on a predetermined time cycle, the reversing double port valves being operated by solenoid controlled air operators actuated through the automatic cycle timer. In order to keep the oxygen purity steady there is a short purge period at each reversal when the product stream from the oxygen regenerators is blown to atmosphere.

The reversing valves on the top of the regenerators which can be

Fig. 1. Flow sheet of 300 ton/day Oxyton.



seen in Fig. 3 are standard double port design with a pressure drop of less than 10 in. water. Like the rest of the plant the size requirements put them in a special class. The low pressure nitrogen valves are 36 in. in size and each valve weighs over a ton. Special neoprene sealing rings had to be installed on the seating surfaces to withstand the wear caused by opening and closing every 3 minutes and at the same time provide absolutely tight shut-off. After the initial problems with seats and sealing ring they have completed over 2 million cycles without serious trouble.

During its passage down the regenerators the moisture and carbon dioxide are deposited on the pancakes and the air leaves the regenerator dry and CO_2-free at a temperature of -270°F. A system of check valves controls the flow of the high and low pressure streams. These check valves had to be especially designed for a very low pressure drop and at the same time be able to stand rapid opening and closing every three minutes. They are of cast stainless construction with specially treated high alloy springs. Part of the check valve assembly for the nitrogen regenerators is shown in Fig. 4.

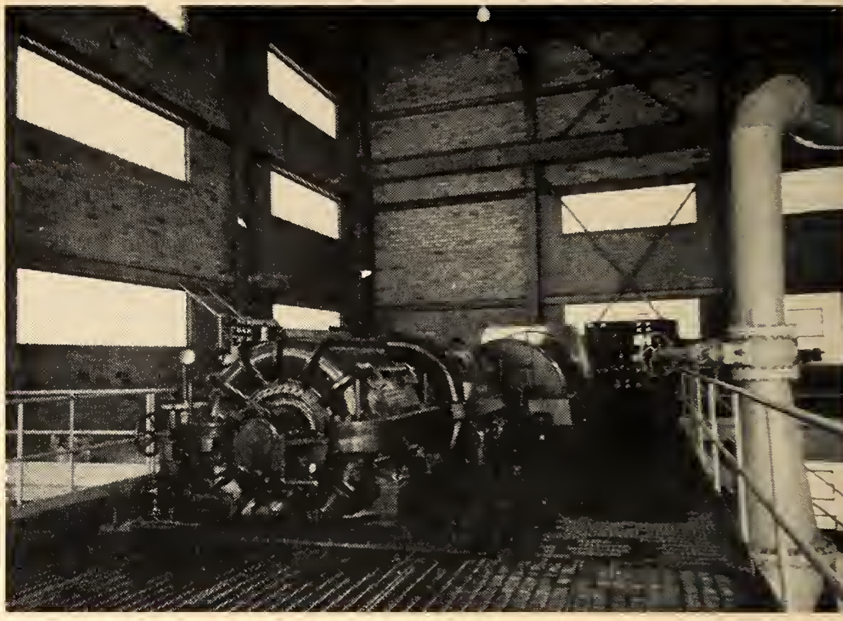
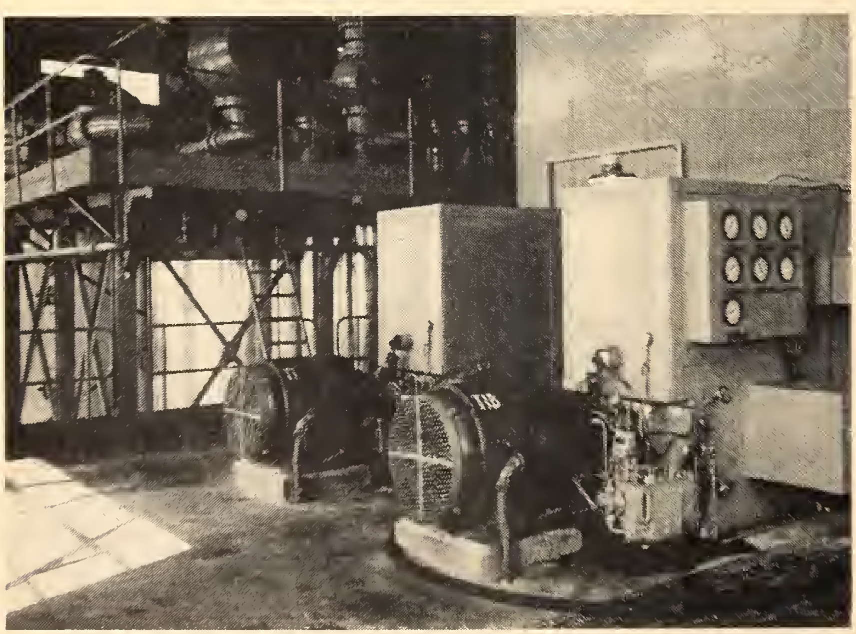


Fig. 2. Air turbo blower.

Distillation Column

The cold dry air from the regenerators and the liquid air from the liquefier provides the feed for the distillation column. The distillation section consisting of three columns, two vaporizers and a subcooler is the most interesting. It is this section which differs in many aspects from the conventional air separation plant. It has been shown[4] that for each mol of pure nitrogen removed in the column overhead, the minimum reflux ratio at the feed plate must be 0.91 mols. This reflux is produced in the main vaporizer or overhead condenser at -290°F at a pressure of 68 lb. per sq. in. gal. One method of reducing the power consumption necessary for air separation is to make the process less irreversible. This can be done if another condenser is provided operating at a higher temperature of -286°F. At this level the minimum reflux ratio is 0.715 mols and hence there is a saving of 0.195 mols on the amount of nitrogen which must be condensed by the overhead condenser. The energy thus saved is used in the second or medium pressure column to produce a further separation. A larger volume of nitrogen is then available for the turbo expanders to produce the required refrigeration.

Fig. 3. Regenerators and turbo expanders.



An examination of the flow sheet is necessary to follow the operation of the distillation columns and how they are inter-related. As stated above, the feed to the high pressure (hp.) column enters at 68 lb. per sq. in. gal. with 94% in the vapor state near its dew point, and the balance as liquid air. A separation takes place into pure nitrogen at the top and a bottoms product called rich liquid containing about 37% oxygen. The nitrogen is condensed in the main vaporizer and part of this condensed nitrogen is withdrawn to provide reflux for the low pressure column. The bottoms liquid is withdrawn, passed through one of a pair of silica gel filters, subcooled by the gaseous nitrogen product and flashed to the medium pressure (m.p.) column at 30 lb. per sq. in. gal. Here a further separation is made to give another pure nitrogen stream and a bottoms containing 55% oxygen. The m.p. column bottoms flow down through the tubes of the intermediate vaporizer at a temperature of -294°F and thereby condensing a part of the vapor stream from an intermediate tray in the hp. column. The intermediate vaporizer acts as a condenser for the lower portion of the hp. column and simultaneously a reboiler for the m.p. column—the 4° temperature difference being available from the differences of operating pressure and the differences in composition. The intermediate vaporizer works in a similar fashion to the overhead condenser of the hp. column (termed the main vaporizer) which is also the reboiler for the low pressure column. The m.p. column bottoms product, after subcooling, is flashed to 5 lb. per sq. in. gal. into the overhead condenser. This liquid, boiling around the tubes, provides the refrigeration to condense the reflux nitrogen inside the tubes by exchange of latent heat. Some of the condensed nitrogen is flashed to the top of the low pressure column for reflux. The liquid not vaporized, and the vapor, enter as feed to the middle section of the low pressure column. In the low pressure column the final separation of the oxygen product occurs.

Fig. 4. Regenerator check valve assembly.

The design and construction of the main vaporizer and the intermediate vaporizer presented the biggest problems in the low temperature section of this plant. In conventional air separation units, and in fact all units up to this time, the main vaporizer (or condenser-reboiler) was located between the two columns, serving as the top of one and the bottom of the other. The intermediate vaporizer could be installed between the 6th and 7th trays in the high pressure column with the tubes open at each end providing the connecting liquid and gas passages. With a unit of 300 tons/day size, handling 30,000 scfm of air, it is almost impossible to use a conventional design. Because of the small (5.5°F.) temperature difference between oxygen boiling at 5 lb. per sq. in. gal. and nitrogen condensing at 65 lb. per sq. in. gal., the depth of the liquid oxygen bath is limited to about 4 ft. To provide the surface necessary, the diameter of the tube sheet would have to be so large that fabrication would be difficult and its installation between the columns would be a major problem. This same situation exists to a lesser degree with the intermediate vaporizer. The problem was solved by redesigning the main vaporizer completely, making it a falling film type. By pumping the liquid oxygen from a sump in the bottom of the low pressure column, the vaporizer could be erected alongside the high and low pressure columns. These columns could then be mounted one on top of the other. In the case of the intermediate vaporizer the condensed liquid air is pumped from the bottom of the shell side back to the hp. column. The pumps used for this purpose are standard vertical centrifugal pumps with specially designed packing, a 40 in. shaft and a totally enclosed impeller. Pumping liquid oxygen or liquid air at temperatures of -280° to -300° F. near the boiling point, presented some difficulties. Quite a few headaches were experienced before satisfactory packings and bushings were developed.

Fig. 5. MP column overhead condenser tube nest.

The medium pressure column condenser is about the maximum size which can be fabricated on the conventional design. It contains over 12,000 ½ in. tubes with a 5 ft. diameter tube sheet. Fig. 5 shows the tube bundle of this condenser during construction, indicating clearly the magnitude of the tubing operation. Compared with the tube bundle of the main vaporizer shown in Figure 6 on a newer design principle and with approximately 2½ times the duty, it will be seen that there is a big difference in the number of tubes and the diameter and thickness of the tube sheet.

For safety considerations an additional vaporizer is added below the main vaporizer, through which most of the oxygen product is withdrawn as a liquid. It is vaporized against condensing nitrogen and combined with the gaseous portion withdrawn from the main vaporizer, goes through a separator and out of the plant via the oxygen regenerators. A slight excess of liquid oxygen is sent through the auxiliary vaporizer so that liquid oxygen washes down to the bottom of the tubes and into the separator. This liquid is purged at frequent intervals, depending on the concentration of impurities in the oxygen. The condensed nitrogen is flashed to the low pressure column as reflux, the flow being controlled by automatic liquid level control. The main features which result in safer operation using the film type recirculation vaporizer and an auxiliary vaporizer have been very thoroughly covered in previous papers[5]. It is interesting to note however that at the time this design was conceived and the plant was constructed, the industry as a whole was not entirely aware of the extreme importance of this phase of oxygen plant operations.

The gaseous oxygen product leaves the oxygen regenerators via the automatic valves and flows directly to the suction of the oxygen turbo blower. This machine incorporates special features for oxygen service such as stainless steel rotor, special seal labyrinths and fully automatic control. The oxygen is compressed to 25 lb. per sq. in. gal. and is carried by a 6000 ft. steam traced pipeline to the copper furnace.

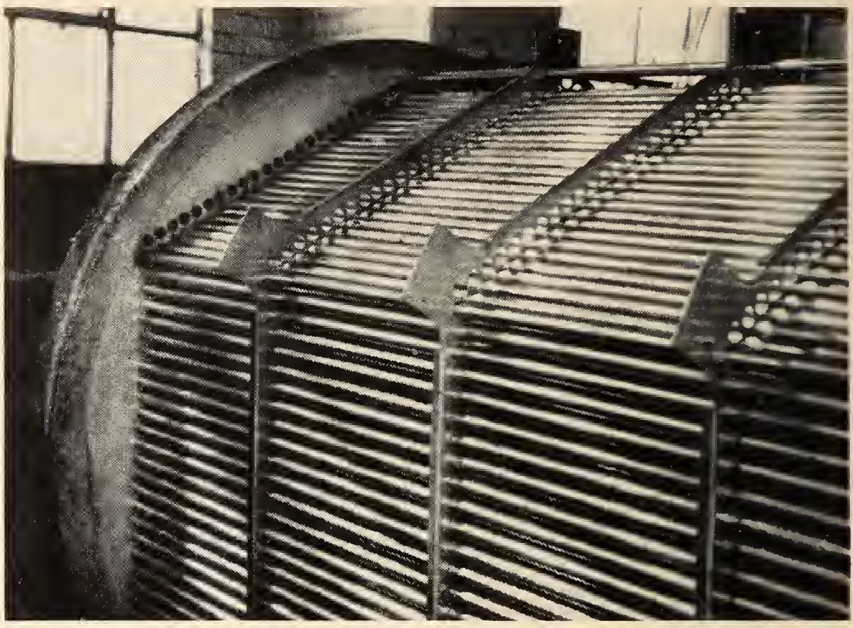


Fig. 6. Main vaporizer tube nest.

Fig. 7. Main control panel.

Like all chemical plants where heat is involved in the process, air separation plants have heat losses. It is perhaps peculiar at first glance to discuss heat losses for a process operating at or near -300° but B.t.u.'s are B.t.u.'s whatever the level. To avoid some confusion, the term refrigeration is normally used. The losses of heat or refrigeration are divided more or less equally into those due to warm end temperature differences and those due to radiation. Careful design of the heat exchange equipment can reduce the warm end losses. Oxytons normally operate with a 5°F. temperature difference between air feed in, and separated products out. By very close grouping of the various vessels and piping and enclosing the whole plant in a sheet metal box and packing this box with specially fabricated mineral wool, it is possible to keep the radiation losses to a minimum.

To compensate for these losses all low temperature separation plants must have a source of refrigeration supply. In some smaller air plants this can be provided from the Joule Thompson effect by expanding cooled air from a very high pressure of 3000 lb. per sq. in. gal. to a final low pressure of 70 lb. per sq. in. gal. The main feature of the Oxyton, namely low power consumption per ton of oxygen produced, would be defeated if the air had to be compressed to any pressure higher than absolutely necessary to carry out the separation. While Joule Thompson refrigeration is used to a small extent by expanding the various liquid streams from a higher to a lower pressure, it represents only a fraction of the refrigeration necessary. The considerations governing Joule Thompson effect refrigeration and refrigeration from an expansion engine or turbine have been covered in some detail in a previous paper[6].

The main source of refrigeration in this plant is provided by expanding nitrogen, removed from the top of the high pressure column, in an axial flow turbo expander. This nitrogen stream, reduced in pressure from 65 lb. per sq. in. gal. to 3 lb. per sq. in. gal., joins the low pressure column overhead and leaves the plant via the sub-coolers and nitrogen regenerators. Two expanders are installed, permitting rapid cooling of the plant during start up by using both in parallel and providing a spare machine during normal operation. They have a single wheel and run at a speed of 10,000 r.p.m. The energy produced in normal operation is 130 kw. and is absorbed by driving a wound rotor motor as a generator. The power recovered is sufficient to drive all the auxiliaries, namely soda pump, cooling water pumps, water circulation pumps and plant lighting. The volume required by the turbo expander varies from 26-28% of the total air feed. This variation depends on the atmospheric temperature, rich liquid filter reactivation, cold desiccator reactivation and the existing pressure drop across of the regenerators due to accumulation of CO_2 and water. Control of the volume through the expander is achieved by changing the number of operating nozzles in the nozzle ring. The adiabatic efficiency is 72%.

Mention has been made of radiation losses and insulation requirements. As radiation is a function of surface area, the casing for the low temperature equipment — termed a cold box — must be of minimum size. Connecting piping and vessel location must be very carefully studied in order to achieve this. The casing consists of a structural steel framework on which are fastened light gage metal panels. The edges of the panel are gasketed and sealed to prevent any air or moisture leak inward. The whole inside of the box is filled with mineral wool packed to a controlled density of 15 lb. per cu. ft. In addition to the mineral wool insulation some of the vessels, in which the operating temperature approach that of the condensation point of air, are individually insulated with 3 in. of foam glass applied direct on the vessel. An exception to the totally enclosed cold box method of insulation is the insulation provided for the regenerators. In this case each vessel is separately insulated with three layers of Zerolite blocks, each layer being 4″ thick and covered with a vapor seal. A thin aluminum sheet is wrapped around the outside to protect the block from damage and preserve the vapor barrier.

Except during initial start-up when the main air compressor is on manual, the plant can be entirely operated from the control panel. All valves used in normal operation are air operated and automatic liquid level and automatic analysis control is used whenever possible. The control panel is shown in Fig. 7. The necessary gas analysis, performed by the operator to check the analyzers, is carried out in front of the control panel so that he does not need to leave the area. A small laboratory is provided adjacent to the control area where routine tests are made.

Considerable care was taken in choosing a location for the plant with reference to smoke and fume concentrations from the Inco refinery. The site chosen is more than a mile away, on the prevailing upwind side of the main plant. Careful acetylene anaylsis of the liquid oxygen in the separator is carried out by the operator and regular checks are made by the control laboratory on the liquid oxygen and the rich liquid. The plant location is such that the Oxyton received the cleanest air possible, however impurities control is not relaxed.

The test runs on this plant, proved that it has an average capacity of 330 tons/day with an average power consumption of 350 kwh./ton. The unit has run for as long as 2½ years without a major defrosting (deriming). The shut-down periods, of necessity, have to be tied to the flash furnace operation and with one exception are every 15 to 18 months. Two operators per shift can run the plant very easily and handle all normal shut-downs and start-ups. When power failure shut-downs occur the plant can be restarted and on stream in less than 2 hours.

It had been predicted many years ago that large capacity air separation plants would eventually be utilized in the chemical and metallurgical industry. With the successful *on stream* operation of the Oxyton at Copper Cliff, on a somewhat larger scale than had been hitherto attempted, this prediction has come true. The whole process of oxygen plant, copper flash smelting furnace and liquid sulphur dioxide plant represents a big advance in technology in the metallurgical industry, each part being a necessary requirement for the proper development of the others.

Acknowledgement

The author wishes to thank Air Liquide and The International Nickel Company for permission to publish this paper and Members of the Engineering and Construction Division of Air Liquide for assistance in preparing this paper.

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HEADQUARTERS COMPUTATION CENTRE FOR THE H.E.P.C. OF ONTARIO

(continued from page 59)

to meet the Ontario Hydro's requirement for a system to collect data from area offices automatically on a sequential basis.

The automatic-manual and manual modes of selection provide considerable flexibility in operation. The ability to condition the equipment to change its mode of operation without interferring with current traffic results in a saving of operator's time.

Dependability is ensured by the independance of manual and automatic circuitry. In addition the use of plug-in components and plug-in sub-assemblies enables service to be quickly restored in the event of a component failure.

The stop feature enables priority to be given to a station and also permits an operator to stop a station sending incorrect tapes or tapes containing errors thus reducing the waste of machine time. No provision was made to indicate to the remote station the reason for the stopping of the transmitter since the HEPC has an order phone circuit. However, it would be possible to provide indications to show that the station was stopped due to the control station giving priority to another station, or due to detecting incorrect tapes or tapes containing errors.

Design and Erection Features of the Vertical Lift Bridges for the St. Lawrence Seaway Authority

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THERE ARE twelve crossings of the new St. Lawrence Seaway; five are vertical lift bridges, three are high level highway bridges, two are rolling bascule bridges, and two are bob-tail swing spans. This paper deals with the vertical lift spans only and these may be located on the map shown. The names of the sites working upstream from the Montreal harbour to Lake St. Francis are: Lower St. Lambert, Upper St. Lambert, Caughnawaga, St. Louis and Valleyfield. These lift spans were all constructed in or close by existing bridges over either the St. Lawrence River or the Beauharnois Canal.

Early in 1955, after having decided upon the general types of bridges for the different crossings, The St. Lawrence Seaway Authority requested assistance from the Dominion Bridge Company to design vertical lift bridges for the C.P.R. crossing of the new canal at Caughnawaga, such technical assistance to include an investigation and report on the relative merits of different operating mechanisms. These services were subsequently extended to include the design of the two crossings of the St. Lambert Lock and to assist in the design of the operating machinery for the St. Louis and Valleyfield crossings of the Beauharnois Canal. The structural design of the last named bridges, as well as the electrical design of all bridges, was carried out by Authority engineers.

As it had been nearly twenty-five years since a major lift bridge had been built in Canada, it was decided that it would be wise to visit similar bridges both in this country and the United States before starting any detail design work. Representatives of the Authority, the Canadian Pacific Railway and the designers participated in this study. First, several lift bridges on the Welland Canal were inspected, mainly to learn what difficulties had arisen in operation and maintenance, since they were built twenty-five years previously. Secondly, several lift bridges in the vicinity of New York City were inspected to investigate the merits of a recent type of lifting machinery. Finally a trip was made to Cleveland where some of the most recently designed bridges were still under construction.

The first major decision which had to be made was whether "Span-Drive" or "Tower-Drive" type of lifting machinery should be used.

With "Span-Drive", the operating machinery is located in a house, mounted on the movable span, and the span is raised or lowered by means of uphaul and downhaul ropes, anchored respectively to the top and the bottom of the tower legs. Any out-of-level of the four corners of the span may be easily corrected by adjustment of the uphaul and downhaul ropes through simple worm take-up devices. This system, which had been used for some fifty years, had proven entirely satisfactory on the vertical lift bridges of the Welland Canal.

The "Tower-Drive" was first developed some twenty years ago in the United States. In this system, the drive machinery is mounted on the tower tops and is coupled through gearing to the counter-weight sheaves. The span is raised or lowered by rotating the counterweight sheaves, so there are no uphaul and downhaul ropes. Originally the problem of maintaining uniform levels at the four corners of the span presented serious difficulties because it was difficult to machine the four counterweight sheaves the same diameter. Also the level was entirely dependent upon the friction between the counterweight ropes and sheaves. Subsequently, to overcome these difficulties special electrical circuits were developed. For a-c wound rotor drive motors, synchronizing control was provided; and for Ward Leonard drives, various forms of speed regulating equipment were provided. After a great deal of investigation, it was decided to adopt the "Span-Drive" type as the cost was lower for bridges of the length required for the Seaway.

One of the troublesome things

about the existing "Span-Drive" bridges was the operating ropes running horizontally from sheaves at the four corners of the span to drums at the centre. Because the ropes could not run through all the posts and diagonals of the trusses, the machinery house had to be placed on top of the span which is very unsightly. Also these ropes tended to drip lubricant on the top chords. To overcome these drawbacks, the drums were placed near the four corners of the span and driven through bevel gearing by a line shaft located down the middle of the span from a central machinery house below the top chords. The line shaft took the place of the horizontal ropes.

The deliberations above did not concern the Upper and Lower St. Lambert bridges for the Canadian National Railways as these bridges had a much shorter span. They only cross the 80 ft. width of the St. Lambert lock while the other three cross the 250 ft. and 200 ft. widths of the canal reaches. The Canadian National Railways' experience with their lift bridges over the Lachine canal had been very satisfactory since they were built fifteen years ago so they decided to use a similar design. In this case, the drive machinery is at the centre of a trussed bridge between the tops of the towers and the span is operated by uphaul and downhaul ropes running over sheaves to anchor points on the span and counterweights respectively. This design also readily lent itself to twinning the lock at a future date.

At this stage, the designs, drawings and specifications for the respective bridges were started and the following sections describe the various parts in detail.

STRUCTURAL

One of the peculiarities of these five lift bridges was that there were four entirely different arrangements of railway tracks and roadways. Only two bridges are alike in this respect. The various arrangements may be seen in the accompanying cross-sections of the bridges.

Lower and Upper St. Lambert Bridges

Two lift bridges were built at the St. Lambert lock in order to avoid interruption of rail and road traffic and to reduce to a minimum interference with Seaway traffic. The lower bridge replaced the south end span of the Victoria bridge and crosses the canal at an angle of 76° 32′ at a point adjacent to the downstream lock gates. The upper bridge crosses the canal at right angles at a point near the upstream lock gates and functions as a by-pass route. Rail and road traffic will normally travel over the lower bridge but when it is raised, the traffic will be by-passed over the upper bridge.

Both bridges are designed so that an additional lift bridge can be added, if a twin lock is ever built.

The cross-section of the lower bridge was governed by the existing format of the Victoria Bridge which consists of double tracks on 13 ft. centres flanked by two 16 ft. roadways cantilevered outside the trusses, all on a .77% grade going down to St. Lambert. The bridge structure was also designed so that the railway grade could be raised in the future, if and when, Victoria bridge is rebuilt. The base of rail would then be nearly 9 ft. higher than it is at present, and the new grade would be .19%. The roadways of the rebuilt bridge would probably cross the canal above the navigation clearance line, so provision has been made in the design for the future removal of the roadways from the lift span with a corresponding modification of the counterweights. The spans of the lower bridge are of the deck plate girder type 107 ft. 7 in. long.

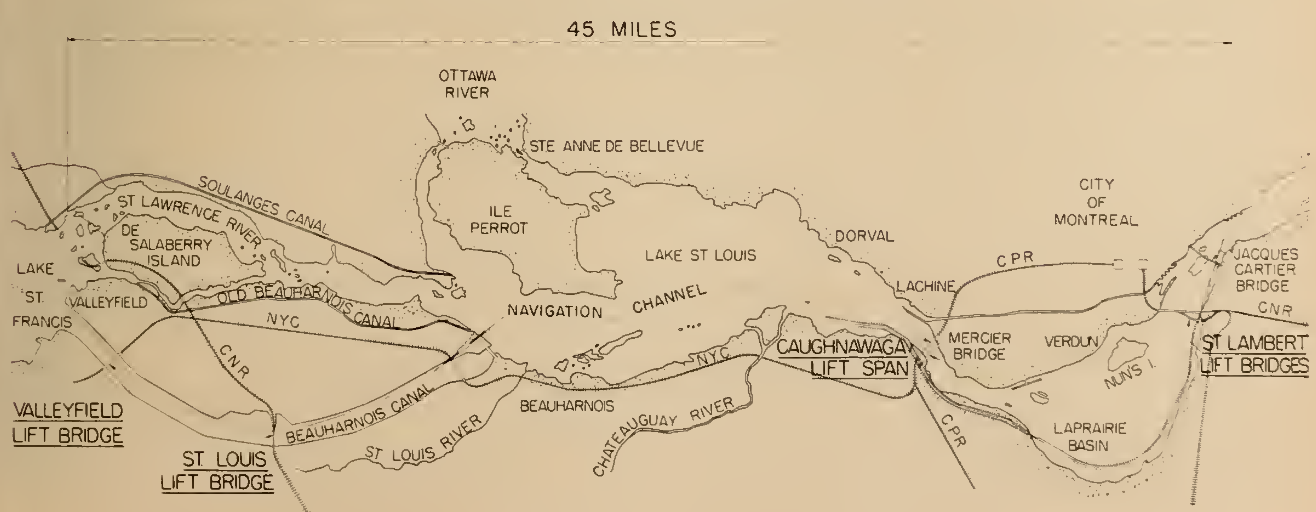
The upper bridge, although it will carry the same traffic is quite different in cross-section. It carries the double tracks on a level grade twenty feet above the roadways. The lift span is therefore a double deck trussed structure 31 ft. 6 in. centre to centre of trusses and 96 ft. long. The two tracks are on 13 ft. centres, laid on a steel deck supported by cross beams. The roadway portion consists of four separate 12 ft. lanes, two inside the trusses, and two cantilevered outside.

Both lift spans have portal girders supported and braced by "A" frames. The counterweight and uphaul operating ropes are attached to the portal girders. They are also arranged to carry future trolley wire systems in case the railway is electrified.

The structures are designed in accordance with the C.S.A. Railway Bridges Specification S1-1950 and the C.S.A. Highway Bridges Specification S6-1952. The railway live loading is Cooper's E60 for both bridges. The roadways of the lower bridge are designed for one 13½ ton truck per lane plus 30% impact. This loading represents the maximum capacity of the existing Victoria bridge roadways. The upper bridge roadways are designed for one H2O-S16.1952 truck per lane plus 30% impact.

The pier members for both bridges are of the dished disc type. The bearing surface of that portion of the pier member assembly that is at-

Fig. 1. Sites of the five vertical lift bridges.



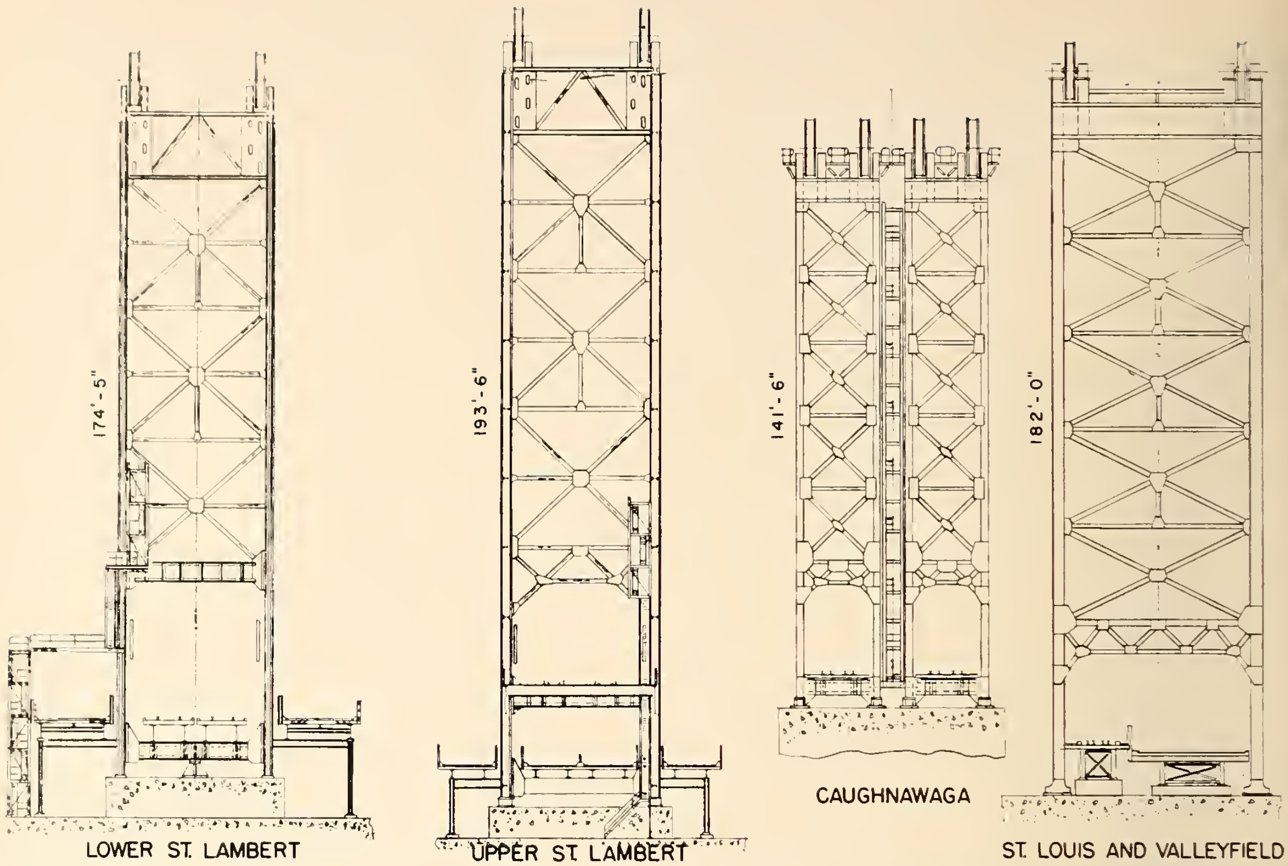


Fig. 2. Cross Sections of the bridges showing the various arrangements of railway tracks and roadways to suit existing bridges. Dimensions shown are from bottom of tower leg to centreline of counterweight sheave.

tached to the lift span consists of a hard bronze plate that can slide on the pedestal part of the assembly which is bolted to the foundation concrete. Although the pier members normally carry live loads only, they are also designed to carry both dead and live loads at 50% increased unit stresses for the emergency condition of the counterweights in the jacked position, with no stress in the counterweight ropes.

For the upper lift span, guide shoes are provided at each corner in the plane of the bottom chord. They engage guide angles located on the centre of the outside faces of the main posts of the tower structure. Jaw type guide castings are used at the fixed end which position the span both laterally and longitudinally during its vertical travel. The guide shoes at the expansion end position the span in the transverse direction only. Guide shoes are placed in a similar arrangement at each corner of the span, in the plane of the top chord. These guides position the span in the lateral direction only. The running surfaces of all guide shoes are fitted with renewable bronze wearing plates. The guides on the tower posts are so arranged that all running clearances are reduced to ⅛ in. during the last two feet of span travel, as it seats. The wind reactions from the top deck of the lift span are delivered to the tower structure by means of the upper guide shoes, so that it was not necessary to provide end portal bracing on the lift span. Because the lower bridge is a plate girder structure, it has only one set of guide shoes, located in the plane of the main lateral bracing system.

A centering device located at the fixed end consisting of a pin supported by the lift span framework, engages a hole in a plate supported by a fixed portion of the structure, and centres the span both laterally and longitudinally. This device also resists the longitudinal wind and tractive forces. Centering devices of the tongue and slot variety, are located at the expansion ends of the lift spans to center the bridge laterally to plus or minus 1/32 in. to ensure proper mating of the rail-breaks.

The counterweights consist of steel boxes filled with concrete. They are rectangular in cross-section and are each 10 ft. wide by 7 ft. deep and 34 ft. long. They have balance block compartments on top with removable panel covers. Each counterweight is guided by four bronze guide shoes, which engage guide angles supported in the bents and towers.

A built-in system of links and pins located in the overhead bridge structure makes it possible, by a series of jacking procedures, to suspend the entire counterweight from the overhead bridge if it becomes necessary to change counterweight ropes, or for any other maintenance reason.

The total weight of the movable span is 596 tons for the lower bridge and 532 tons for the upper bridge. The normal lift of the lower bridge is 96.5 ft. and of the upper bridge 100 ft. which is needed for a 120 ft. vertical clearance for the Seaway. A 3 ft. overtravel in excess of 120 ft. clearance was also provided.

The tower structures of both bridges are similar and some parts are identical. The general principle of framing is similar to the C.N.R. vertical lift bridges over the Lachine canal.*

An overhead bridge carries the machinery house at the mid-span

*(Refer: Engineering Journal, July 1946, Page 415.)

point, and is supported at one end by a bent, and at the other end by a rectangular tower, which gives longitudinal stability to the entire structure. The present arrangement as seen in elevation has a lopsided appearance, however, the tower is designed for the addition of another overhead bridge and bent, at the time a future twin lock is built. The complete structure would then be more symmetrical, and not unlike the Lachine canal bridge.

The south approach span for the upper bridge is, except for its length, similar to the lift span, and is identical in many details. It is designed so that it can be easily converted into a lift span if the twin lock is built.

The total length of the lower bridge structure is approximately 258 ft. being equal to the length of the Victoria bridge span which it replaced. The total length of the upper bridge project is 314 ft.

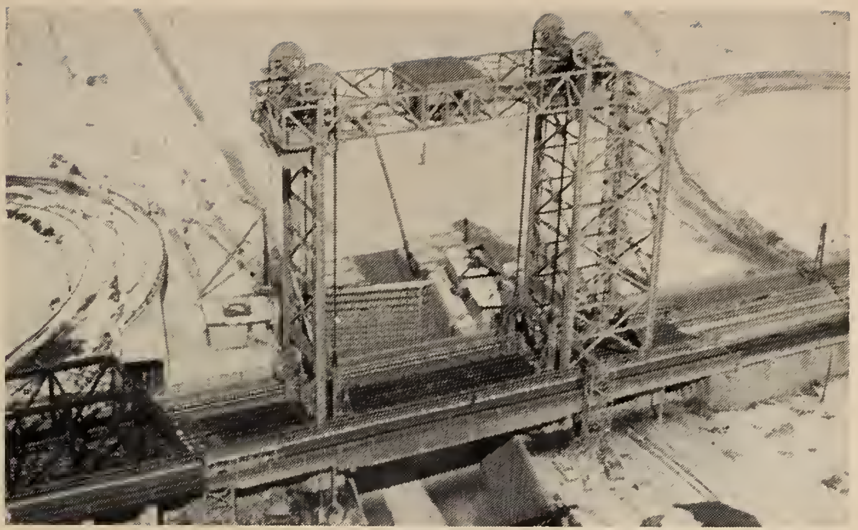


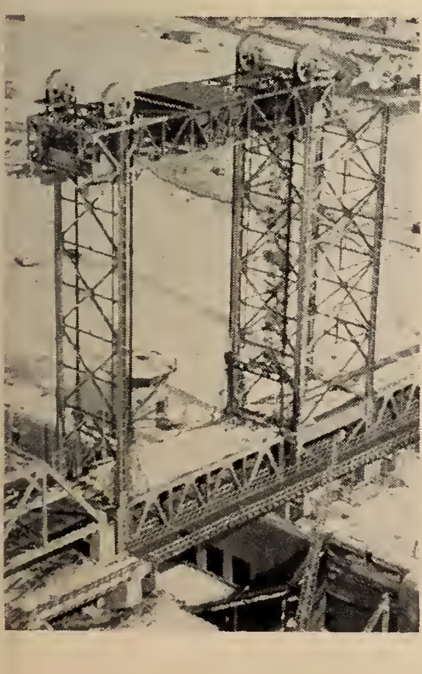
Fig. 3. Lower St. Lambert lift bridge which replaced the south end span of the Victoria bridge. It is located just downstream from the lower lock gates of the St. Lambert lock.

Caughnawaga Bridge

The two tracks of the Canadian Pacific Railway cross the 250 ft. wide canal at an angle of 59°. They are 27 ft. centre to centre, lie on a grade of .5% and are carried separately on twin vertical lift spans. The two spans are offset a distance of about 16 ft. in the longitudinal direction, because of the skew crossing.

Twin spans were built in preference to a single double track structure. The main reason for using twin spans was because they provided greater flexibility of railway operation. If one span were inoperative because of accidental or mechanical causes, the other could carry the traffic during the emergency. The railway has provided crossovers between their tracks so that either bridge may carry both northward and southward traffic.

Fig. 4. Upper St. Lambert lift bridge will be used to by-pass traffic when the lower bridge is raised. It is located just upstream from the upper lock gates of the St. Lambert lock.



A cost analysis was made to determine the economy of using low-alloy steel, in the lift span trusses and floor system, and in the tower main posts. This analysis indicated a small saving in material cost but it was largely offset by increased shop costs due to the use of two kinds of steel in the same structural components. Because the estimated saving was not large enough to be significant, and also because the railway expressed a preference for the use of medium structural steel as it is easily weldable in case emergency repairs are required, it was decided not to use low-alloy steel.

The main trusses of the lift span are 19 ft. centre to centre and have a total length of 322 ft. They are 45 ft. deep at the centre and provide space for the machinery house between the railway clearance and the top lateral bracing system. The ties are supported on 42 in. deep plate girder stringers spaced 8 in. apart. Special contraction joints were placed in the stringer system at the third points to prevent tension stresses being induced in them. Perforated plates were used instead of lacing on structural members, where practicable, for ease of maintenance and good appearance.

Double web girders 5 ft. deep join the two trusses just above the railway clearance at each end of the span. The counterweight ropes are attached to these girders, at each corner of the span.

The structure is designed in accordance with the C.S.A. Railway Bridges Specification S1-1950. The railway live loading is Cooper's E70.

The lift span fixed-end pier members are in the form of a jaw type weldment attached to the span. As the span seats, this jaw engages a pin located in a pedestal weldment bolted to an extension of the base slab on which the main tower post seats. These pier member units accomplish the final longitudinal centering of the lift span during its last two inches of travel, and when the span is closed, they carry all the longitudinal wind and tractive forces. The expansion-end pier members are made of weldments of the rocker type. They are spring loaded to ensure that the rockers will be vertical when the span seats.

The span guide shoes are similar to those described for the Upper St. Lambert Bridge.

To ensure perfect lateral mating of the rail-break assemblies, centering devices were provided under the end floorbeams at each end of the span. These "tongue and slot" weldments centre the lift span laterally to ± 1/32 in. during the last 2 inches of travel, as it seats.

Each counterweight consists of a rectangular steel box, 11 ft. 9 in. thick, 16 ft. wide and 40 ft. 3 in. high, filled with concrete. The ⅜ in. thick skin plate is supported by systems of horizontal and vertical ribs, giving an unsupported panel approximately 4 ft. square. The plate is designed for the hydraulic pressure from wet concrete at the time the box is being filled. A system of struts in two directions gives rigidity to the panelling. A grillage of timbers, attached to the bottom of the counterweight, act as a buffer, in case the counterweight should strike the deck of the bridge due to accidental overtravel of the lift span. The upper portion of the counterweight box consists of a compartment for the placing of concrete balance blocks. This block storage space is weathertight and is entered by means of a trap door. Each counterweight is guided by four bronze guide shoes, which engage guide angles supported on the tower bracing.

The total weight of each movable span is 955 tons. Because the base of rail is some 48 ft. above high water, a normal lift of only 78 ft. is required for the 120 ft. vertical clearance needed for the Seaway. A 3 ft. overtravel, in excess of the 120 ft. clearance, was provided.

Each tower supports two 15 ft. counterweight rope sheaves at an elevation some 141 ft. 6 in. above the pier top. The front tower posts are vertical and each pair carry the dead load of one half of the lifted span and one counterweight, as well as being subjected to bending loads from the lift span guide shoes, and wind overturning forces. These were built up of plates and angles to form an "H" cross-section. The tower back legs are essentially parabolic in outline and are relatively slender. The bottom portion of the tower acts as a 66 ft. span bridge with the same type of deck as is used on the lift span.

Fig. 5. Caughnawaga twin lift bridge which provides flexibility of railway operation. Cross overs were provided between the two tracks approaching from either side so that if one span is damaged all trains can use the remaining span.

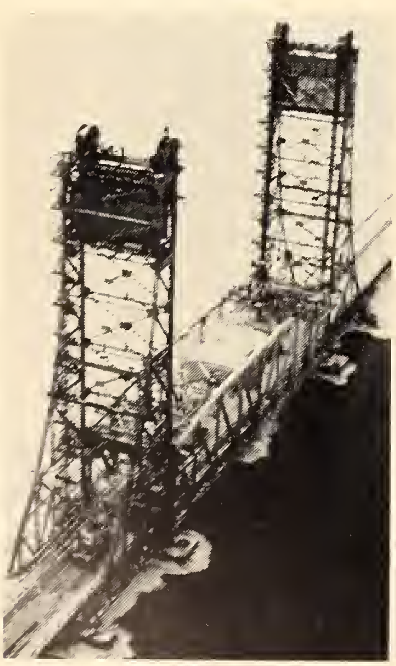


Fig. 6. St. Louis lift bridge which replaces two spans in the north end of the St. Louis bridge.

Girders are incorporated into the longitudinal faces of the tower, a short distance below the bottom of the counterweights when they are in their upper position. Temporary beams can be laid across these girders from which the counterweight may be jacked, and supported temporarily, if and when it becomes necessary to renew counterweight ropes. The fixed end of the balance chains are also supported on a transverse beam framed to the towers.

Deck plate girder approach spans, 55 ft. long, flank the towers at both ends of the project, to give the approach embankment room to spill around a buried type of abutment pier.

The total length of steel structure is 577 ft.

St. Louis and Valleyfield Bridges

The St. Louis and Valleyfield bridges both cross the Beauharnois canal at right angles and are level. They span an opening 199 ft. 6 in. wide between two piers flanking the Seaway channel. Provision was made when building these bridges about thirty years ago for the future installation of lift bridges. In succession there was a 75 ft. span, two 100 ft. spans, and then another 75 ft. span. The piers for the 75 ft. spans were made wide so that towers could be erected over them. The two 100 ft. spans were anchored in such a manner that they could easily be removed, the extreme ends resting on the wide piers for the towers, and the mating ends on a temporary pier. The new lift span replaces the two 100 ft. spans and their centre supporting pier.

Each of these bridges carries a single railway track and a double lane roadway. In cross section they look alike but there are slight varations due to different railway loadings and roadway widths. The roadway on the St. Louis bridge is 18 ft. wide and on the Valleyfield bridge 28 ft. wide. The truss centres are respectively 43 ft. 10 in. and 49 ft. 8 in.

In both cases all material in the trusses on the railway side, except gusset plates and stiffening angles, is of ASTM A-242 low alloy steel.

These two structures are designed in accordance with the C.S.A. Railway Bridges Specification S1-1950, the AREA Specification for Movable Bridges (Valleyfield only) and the C.S.A. Highway Specification S6-1952. The railway live loading at St. Louis is Cooper's E60 and at Valleyfield Cooper's E70. The roadways are designed for a live load of H20-S16 plus 30% impact or U-100 per lane.

The various structural parts of both these bridges such as the pier members, span and counterweight guides, centering devices and towers are similar to the Caughnawaga bridge and need not be described again. The counterweight box dimensions are 11 ft. 9 in. thick, 14 ft. 6 in. high, by 40 ft. 7 in. wide at St. Louis and 46 ft. 5 in. wide at Valleyfield.

The total weight of the St. Louis span is 1212 tons and the Valleyfield span 1402 tons. A normal lift of 113 ft. 6 in. and 114 ft. 6 in. respectively is required for the 120 ft. Seaway clearance. A 3 ft. overtravel, in excess of the 120 ft. clearance, was again provided.

Each tower supports two 15 ft. counterweight rope sheaves at an elevation 182 ft. above the pier top.

The total length of each of these lift bridges is 370 ft. including the original 75 ft. spans beneath the towers.

MECHANICAL

The mechanical parts of all the bridges were designed in accordance with the C.S.A. Provisional Specification for Movable Bridges (First Draft).

Counterweight Ropes

The counterweight ropes for the St. Lambert and Caughnawaga bridges were all cut from a special Grade 110/120 steel wire rope, 1⅞ in. in diameter, 6 x 19 construction, with an impregnated hemp centre. A breaking strength of 320,000 lb. was specified, and this figure was included in the requirements as the minimum value to be shown by any full size destruction tests.

The requirements for prestressing were to stretch the rope gradually to a tension of 48,000 lb., a load safely over the maximum value likely to occur in service, and also a value which would not squeeze out the lubricant used in their manufacture. This load was held for a period of time until no appreciable stretch was observed. The tension was then gradually released to about 11,000 lb. and again brought up to the marking load of 32,000 lb.

The metallic area of each rope was calculated to be 1.45 sq. in., and a factor of safety of 10 was required on the direct tension, thus giving an allowable unit of 22,000 p.s.i. The bending stress induced by passing the rope over the 15 ft. sheave was assumed to be:—

$$.7\,Ed/D \quad \text{where} \quad \begin{aligned} E &= \text{modulus of the wire} = 28{,}500{,}000 \\ d &= \text{diameter of each wire} = .121 \text{ in.} \\ D &= \text{diameter of the sheave} = 180 \text{ in.} \end{aligned}$$

This being equal to 13,400 p.s.i., therefore, the maximum allowable combined unit stress was 35,400 p.s.i. This gave a factor of safety of 6.2, the specified allowable being 5.

The counterweight ropes were calculated on the basis of equal distribution of weight between the four corners of the span. The St. Lambert bridges have twelve ropes per corner and the load in each rope is 24,800 lb., with a direct tension unit of 17,100 p.s.i. This was well under the allowable, but the ropes were designed to be the same as will be used on a possible future and larger span when the lock is twinned. The Caughnawaga spans have sixteen ropes per corner and the load in each rope is 29,800 lb., with a direct tension unit of 20,600 p.s.i.

The counterweight ropes for the St. Louis and Valleyfield bridges were designed and prestressed in a similar manner but required rope 2⅛ in. in diameter. These spans have sixteen ropes per corner and the load in each rope is 45,300 lb., with a direct tension unit of 26,600 p.s.i.

Counterweight Sheaves

The counterweight sheaves are all 15 ft. in diameter and four in number for each span. They were fabricated by forming and welding together A.S.T.M. A.373-54T. structural steel plates. Rough turned forged steel trunnion shafts were inserted into the sheave webs and arms, and were integrally welded into place. By using this construction, the sheaves were much lighter than if they were cast. Also time and labour was saved over the conventional cast steel sheaves where the hubs have to be bored and key-seated, and the shafts fitted by either heating the sheave or cooling the shaft. The

Fig. 7. Counterweight sheaves with integral trunnions fabricated in welded steel.

sheaves were stress relieved before machining.

For the counterweight sheaves steel cast pillow blocks, heavily bushed with phosphor bronze, were seated on structural members at the top of the towers. Deep reservoirs, with plate steel lids, were cast integral with the bearing covers for storing grease.

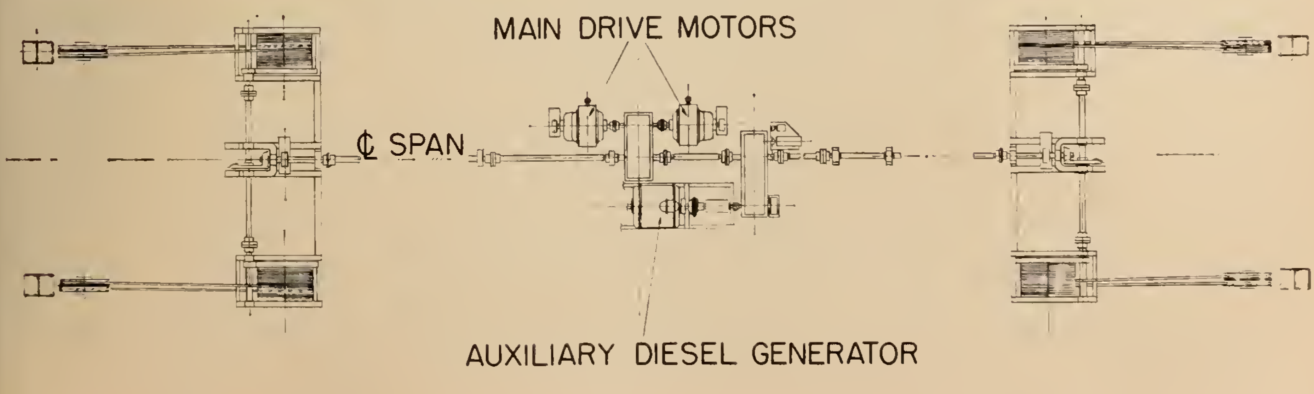
Grease channels were machined in both the trunnion shafts and the bushings. Pressure grease fittings were supplied for the bushings which allows the journals to be lubricated independently to facilitate starting up atfer a winter shutdown.

The use of rolling type bearings was considered but the extra cost of them over bronze bushed ones was decided to be too high considering the many years trouble-free service given by the bronze type on the Welland canal bridges.

Balance Chains

Weight was supplied in the form

Fig. 8. Machinery layout at Caughnawaga showing main drive machinery at the centre, and the operating drums at the ends, of the span.



of chain links to balance the weight of the counterweight ropes, as they move over the sheaves from the span side to the tower side and vice-versa.

On the St. Lambert bridges, one end of each balance chain is connected to the counterweight and the other end to the movable span. These chains hang down outside of the railway track clearance limits, and in order to prevent any encroachment, due to swing of the chain from wind or other causes, the lower part of the chain passes around a flanged wheel which is secured to a structural post. The weights of these wheels are carried by the chains and the connections to the post are such that the wheels have a free vertical motion to take care of variations in the length of chains due to differential temperature changes or wear. The chains are made of cast iron blocks and links connected together by steel pins, the weight being approximately the same, per foot length, as one group of counterweight cables. The counterweight of these bridges was theoretically equal to the weight of the span.

The Caughnawaga, St. Louis and Valleyfield spans have a different type of balance chain to that described above. This chain hangs in the form of a catenary, under the counterweight, one end being attached to the counterweight and the other end to the tower at a point slightly above the mid-point of the span travel. This makes the effective length of the chain half the length of the unbalanced counterweight ropes. To maintain a theoretical balance at all positions of travel the main counterweights are lighter than the span by an amount equal to the weight of the counterweight ropes and the balance chains are twice the weight of the counterweight ropes. The chain consists of cast iron blocks, with lugs, connected together with steel pins.

Table I. Operating Rope Forces (lb.) and motor torques starting, accelerating and running for balanced and unbalanced operation.

	Case "A" Normal Time			*Case "B" Excess of Normal Time*		
Lift Span Force due to	*Start*	*Accel.*	*Run*	*Start*	*Accel.*	*Run*
Lower St. Lambert						
Friction	27,950	19,350	19,350	27,950	19,350	19,350
Inertia		11,320			6,740	
Rope Bending	3,240	3,240	3,240	3,240	3,240	3,240
2½ lbs. Wind	14,000	14,000	14,000	14,000	14,000	14,000
2½ lbs. Ice				19,000	19,000	19,000
Total Force	45,190	47,910	36,590	64,190	62,330	55,590
Corresponding motor torque (foot-pounds)	1,000	963	737	1,420	1,253	1,118
Caughnawaga						
Friction	56,000	38,600	38,600	56,000	38,600	38,600
Inertia		14,950			8,880	
Rope Bending	5,250	5,250	5,250	5,250	5,250	5,250
2½ lbs. Wind	13,000	13,000	13,000	13,000	13,000	13,000
2½ lbs. Ice				13,000	13,000	13,000
Total Force	74,250	71,800	56,850	87,250	78,730	69,850
Corresponding motor torque (foot-pounds)	1,430	1,235	978	1,680	1,360	1,205
Valley field						
Friction	86,000	59,500	59,500	86,000	59,500	59,500
Inertia		29,400			13,100	
Rope Bending	9,750	9,750	9,750	9,750	9,750	9,750
2½ lbs. Wind	28,000	28,000	28,000	28,000	28,000	28,000
2½ lbs. Ice				28,000	28,000	28,000
Total Force	123,750	126,650	97,250	151,750	126,550	125,250
Corresponding motor torque (foot-pounds)	3,260	2,930	2,250	4,000	2,920	2,900

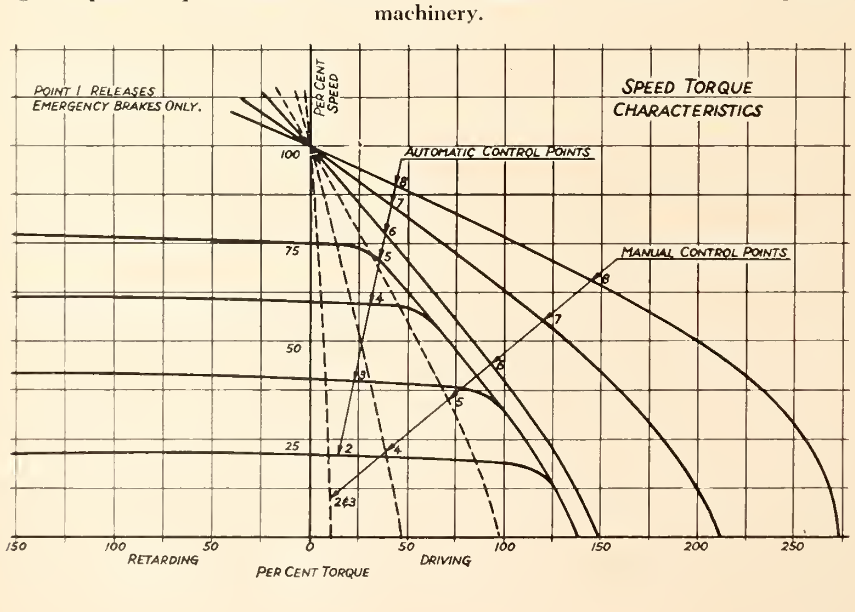
Span Locks

In order to insure proper seating of the spans, a locking device is provided at each corner of each span. The locks consist of a toggle lever type mechanism and are so designed that the contacting arms or hooks, of which there is one to each lock, are swung outwards and downwards (as on the St. Lambert spans) or outwards and upwards (as on Caughnawaga, St. Louis and Valleyfield spans) in the driving operation until they bear against special brackets on the span or the towers as the case may be. As the toggle straightens under this power stroke the hooks can develop enough pressure to force the span down tight on to its shoes and so line up the rails and roadways vertically.

On the St. Lambert spans these locks are mounted on structural steel girders anchored to the tower piers. The hook locks down on brackets on the movable span floor beams. They also have another function to perform. These spans to all intents and purposes have no dead load reaction, and as the bridge shoes are placed inside the cantilevered roadways, an overturning moment can occur when one roadway is loaded and the other unloaded. The span locks are mounted close to the bridge shoes, and are designed to resist this overturning load, as a static condition.

On the Caughnawaga, St. Louis

Fig. 9. Speed torque characteristics of the automatic a-c. control of the operating machinery.



and Valleyfield bridges, transverse struts are placed at the ends, parallel to the lifting girders and in the plane of the top chord upon which the span lock mechanism is mounted. The hooks bear up against special brackets mounted on the front legs of the towers.

Operating Machinery

The operating machinery for the St. Lambert bridges is located in weatherproof steel machinery houses on the overhead structure. Each set of machinery consists of four grooved drums of welded steel construction, two on the upstream side and two on the downstream side of the bridge. Each pair is driven by a common cross shaft, which has a pinion at each end meshing with gears on the drums. The cross shaft is driven at the centre by means of a double herringbone gear rolling bearing reducer coupled to the two 150 hp. motors.

There are eight operating ropes for each span, one uphaul and one downhaul at each corner, each 1¼ in. in diameter, 6 x 19 construction. One uphaul rope and one downhaul rope is wound on and anchored at opposite ends of each drum. The four uphaul ropes lead from the underside of the drums over large guide sheaves, at the corners of the overhead structure, to the span. The four downhaul ropes lead from the topside of the drums, over guide sheaves and are attached to the counterweights. To raise the bridge the operating machinery and ropes exert an upward pull on the movable span, and to lower the span, an upward pull on the counterweights. The operating ropes are anchored to the span and counterweight by a self-locking worm and take-up drum. The ropes are pre-tensioned by applying torque to the worm shaft and are prevented from loosening due to the self-locking feature of the worm and worm gear.

A gas engine is fitted to the machinery on the lower St. Lambert bridge only, for emergency purposes. It consists of a vee-eight 75 hp. gasoline engine connected to the machinery cross shaft through a spur gear rolling bearing reducer and clutches. A friction clutch and a slip type coupling is inserted between the engine and the gear reducer and a sliding jaw type clutch and reversing gear is incorporated in the reducer.

Thrustor operated brakes are mounted on the back end of each motor and also, at each end of the drive cross shaft.

The Caughnawaga, St. Louis and Valleyfield bridges have the operating machinery installed on the lift spans. Four, double pitch, grooved welded steel drums are attached just below the top chords of the trusses, one at each corner near the ends of the spans. They are connected to the machinery at the centre by means of transverse and longitudinal shafting through suitable spur and bevel gear reductions all turning in bronze bushed bearings. The longitudinal cross shaft is driven at the centre by means of a double herringbone gear rolling bearing reducer coupled to two 150 hp. motors at Caughnawaga and two similar reducers coupled to four 150 hp. motors at St. Louis and Valleyfield.

Fig. 11. Railway girder span is being lifted into place at Lower St. Lambert showing second track in readiness for trains.

Fig. 10. 109 ton tower derrick used to construct the lower St. Lambert bridge.

There are sixteen operating ropes for each span, double ropes being supplied at each corner for each of the uphaul and downhaul motions. The ropes are 1 in. in diameter at Caughnawaga and 1¼ in. in diameter at St. Louis and Valleyfield, 6 x 19 construction. The uphaul ropes, in pairs, lead from underneath the drums around large deflector sheaves, up the tower face to guide sheaves at the top and then to the self-locking take-up drums fixed to a cross-girder at the top of the towers. The downhaul ropes, in pairs, lead from the top of the operating drums, over large deflector sheaves down towards the base of the tower and thence to the take-up drums fixed to the tower legs.

An auxiliary diesel generator was supplied for each of the Caughnawaga, St. Louis and Valleyfield bridges. The diesel engine, with reversing gear, was mechanically connected to the main drive shaft by a helical gear rolling bearing reducer. A friction type clutch was placed between the engine and the gear reducer and a jaw clutch was inserted at the drive shaft.

Thrustor operated brakes are mounted on the back end of each motor and also at each end of the longitudinal shaft.

Pneumatic Buffers

Air buffer cylinders are installed, on all bridges, to check or cushion the end of the downward vertical movement of the lifted spans. The piston rods have an adjustable end piece of hardened steel which bears on plates anchored to the piers. The exhaust air is piped through a control needle valve and an oil fog lubricator to the rod end of the buffer cylinder. This means that the cylinder walls are sprayed with oil each time the buffer operates. A steel compression type spring is also fastened on the outside around the piston rod to ensure that the piston falls into operating position.

Rail Breaks

Manganese steel rail breaks of the sliding wedge type were provded at the St. Lambert and St. Louis bridges. These reciprocate horizontally by means of an electric motor driving, through a worm gear reducer, levers and links which form a self-locking toggle, thus fixing the rail wedges against movement from the wheels of the train. A slightly raised part lifts locomotive and car wheels as they pass the rail gap thus minimizing noise and impact.

At Caughnawaga and Valleyfield the rail break design is similar to some recent ones installed in the United States. There are no sliding parts, the rails being lapped together at the breaks. They practically eliminate noise and impact and allow trains to travel at full speed.

Operating Torques and Speeds

The specifications called for these bridges to be raised and lowered in a normal operating time against the forces caused by:—

(Case A) Friction, inertia, rope bending and wind.

In a period of time somewhat slower than normal against the forces caused by:—

(Case B) Friction, inertia, rope bending, wind and an additional unbalanced force caused by ice.

The table shown gives these forces as applied to the operating ropes of the various bridges.

The St. Lambert bridges are designed to open in 90 sec. normal time, 15 sec. being allowed for the rail and span locks, leaving 75 sec. to raise the bridge 96 ft. 6 in. This corresponds to a speed of 1.49 f.p.s at the operating ropes. The Caughnawaga bridge is designed to raise a distance of 78 ft. in 75 sec., a speed at the operating ropes of 1.2 f.p.s. The St. Louis and Valleyfield bridges are designed to raise a distance of 114 ft. 6 in. in 75 sec., a speed at the operating ropes of 1.64 f.p.s. Using suitable gearing, the torques in ft.-lb. at the motor corresponding to the rope forces, at the various bridges were calculated. These are also shown in the accompanying table.

Motors of 150 hp. running at about 860 r.p.m. were selected as suitable machines to provide the above torques. The maximum torque required by the motor would be Case "B" starting. With a voltage drop of 10% the maximum starting torque would be 270% of the normal torque.

Brakes

There are four thrustor operated brakes fitted to the machinery for each movable span of the St. Lambert and Caughnawaga bridges and six for each movable span of the St. Louis and Valleyfield bridges. The units on the back end of the motors are the decelerating brakes and the units on the drive shafts are holding or emergency brakes. These latter brakes are about half torque and have a time lag so that normally they do not come on until the machinery has stopped.

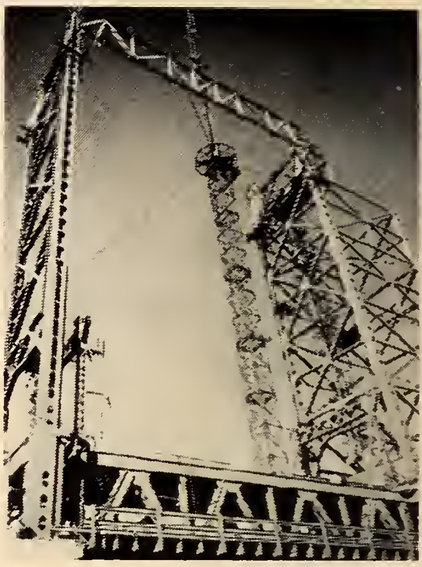


Fig. 12. 20 ton tower derrick used to construct the upper St. Lambert bridge.

Fig. 13. Falsework upon which both the Caughnawaga spans were constructed, one after the other.

ELECTRICAL

The success that has been attained in more recent years in operating a-c. wound rotor induction motors at subsynchronous speeds with good stability encouraged a search for an a-c. drive suitable for lift bridge operation. The development of saturable reactors and the applications of magnetic amplifiers led to schemes particularly suitable to bridge operations. Investigations showed that an a-c. drive employing wound rotor induction motors could be built to satisfy the operating requirements at a moderate capital cost. The decision was therefore made to use a-c. drives at 500 v., 3 phase.

A scheme controlling each winding of a two circuit motor was supplied by Canadian General Electric Co. Ltd. for the Caughnawaga bridges. An unbalanced voltage scheme was supplied by Canadian Westinghouse Co. Ltd. for the remainder of the bridges.

Speed control is entirely automatic for both schemes. Each speed point on the master switchsets up a reference voltage. A tachometer generator is geared into the drive and generates a voltage which is compared with the reference. This comparison is fed to magnetic amplifiers for regulation of the control equipment to maintain the drive at the reference speed. Once a speed is set by the operator, the equipment is automatically controlled to hold that speed regardless of whether the load requirement is a high or low torque, motoring torque, or braking torque. In the normal raising or lowering of a span, the speed should be a maximum for most of the travel to reduce the time of operation. However, in the nearly open and nearly closed positions, the speed should be reduced to approximately 20% of maximum speed. At each of these positions, a limit switch has been provided to set up a reference speed of 20% regardless of the position of the master switch. A second limit switch operates at each extremity of travel for the final stop and application of electric holding brakes. After the limit switch operates to set up a reference speed of 20%, a centrifugal switch is included in the circuit which stops the motion if the speed is not reduced in a reasonable time.

The control for both the two circuit motor scheme and the unbalanced voltage scheme is essentially static and employs few contactors. The use of saturable reactors not only eliminates many contactors but also provides nearly stepless speed and torque control. In addition, the transition from a low torque to a high torque or vice versa is done without shock. It is anticipated that the period for maximum torque change will not be less than 0.2 sec. The period for modern d-c. adjustable voltage control is about 0.3 sec. and this is usually accepted as the ultimate in smoothness. By contrast, the period for a wound rotor motor controlled by contactors and resistors is of the order of 0.01 sec.

Standby Generators

The standby diesel engine driven generators are unusual in that the generators are 25 cycle machines. It is not necessary in most bridge applications to supply standby equipment equal to normal capacity as a reduction in speed for emergency operation is quite acceptable. This results in a lower power requirement permitting the use of an engine generator set of reduced capacity and consequently reducing the cost. The reduction in speed in this case is accomplished by operating the equipment at 25 cycles. However, the voltage must be reduced to approximately 230 v. The arrangement may therefore be considered as an electrical speed changer. It is interesting to note that the automatic control equipment obains satisfactory operation of the motors when operating on 25 cycles.

Control Desks

The bridge operator controls all the operations from a desk type control unit which was designed specifically to facilitate and simplify the procedure. This unit contains the master switch, selector switches, push buttons, meters and other devices and instruments necessary for proper operation. Indicating lights show the position of the limit switches. A position indicator of the self synchronous type shows the height of the span. For the bridges where the normal operation is done from a control house separate from the bridge, a second control desk is supplied in the machinery house. This permits operation directly from the bridge if necessary or desirable.

Fig. 14. Translation of span at Caughnawaga on twenty wheel trucks running on rails.

Fig. 15. Floating span into place at the Valleyfield bridge.

ERECTION

Lower St. Lambert Bridge

As mentioned previously, the lower vertical lift bridge at St. Lambert replaced the south end span of the existing Victoria bridge.

At the start of the project, the highway traffic was diverted off the bridge. Railway traffic, however, was maintained at all times. In general both tracks were in use, but periods of single track operation were arranged to permit work on the structure supporting the other track. In general these periods were limited to 6 or 7 hours, although a few longer periods were required.

In view of the continuous heavy railway traffic and the existing truss to be removed, it was necessary that the main hoisting equipment be independent of the bridge structure. All the high lifting and heavy lifting for this project was done with a tower derrick standing on the floor of the lock.

A 150 ton guy derrick, with 202 ft. mast and 160 ft. boom was used. It was mounted on a 182 ft. steel tower standing on a dished disc bearing on the floor of the lock. The tower was guyed with four double guys at 90° to each other, while the mast had eight guys at angles governed by the roadway layouts. The derrick was rigged for 109 tons on this project. The location in the middle of the lock was necessary to reach both ends of the overhead structure from one set-up.

The cantilever roadways were removed using light cranes as soon as highway traffic was diverted. Then in order to dismantle the existing trusses, it was necessary to support each floor beam of the existing span for both dead load and live load. The four floor beams over the lock were supported on a 94 ft. steel truss span. There were three trusses, one on the centerline and one 13 ft. 10 in. each side of centerline, in order to permit removal of the floor beams half at a time. All field connections were high strength bolted. The remaining floor beams were each supported on three steel columns similarly located and braced with steel angles.

All the falsework was constructed about 2 in. clear of the existing trusses to permit free truss deflection. Load was transferred to the falsework by stopping all traffic, driving wedges at all points of support, and burning through the bottom chord of the existing trusses at the center. This period of about 3 hours was the only time that traffic was stopped on both tracks for more than a few minutes. As soon as the load was transferred to the falsework, the existing trusses were removed in as large pieces as possible by the tower derrick and two cranes.

Simultaneous with the falsework erection and truss dismantling described above, the bottom tiers of the towers were erected, with the tower base struts and lifting girders in between the old floorbeams ready to support the railway spans. The various railway girders were assembled at ground level into spans consisting of two girders, complete with bracing. In the case of the shorter spans, all the timber ties were installed in advance. In the case of the main lift spans only every fourth timber tie was installed in advance to limit the weight to 109 tons.

To permit erection of each span, traffic was stopped on one track right after the morning peak period. As soon as the rails were removed by the railway company, the existing ties, stringers, and half floor beams were removed by the cranes and tower derrick, following which the new span complete with ties was lifted into place. Typical time for the shorter spans was about 6 hours. For the lift spans about 11 hours were required, as falsework had to be removed to clear the deep girders and the remainder of the ties had to be placed.

As soon as portal struts of the towers were erected, Bailey bridging was suspended from them extending the entire length of the overhead structure. The Bailey bridging was covered with a 12 in. timber mat 36 ft. wide. The principal purpose of the mat was to protect passing trains from any bolts, pins, or other light objects which might be dropped from above. In practice it also proved useful as a working platform for laying out light steel for the structure above.

The remainder of the superstructure, including towers, overhead trusses, machinery, counterweight sheaves, counterweight boxes, counterweight concrete, and auxiliary counterweights, was then completed with the use of the tower derrick. Because of the great capacity of the tower derrick, whenever possible sub-assemblies were assembled and in many cases riveted on the ground before raising, to minimize the amount of high work.

Erection of the tower derrick started in September, 1957. Load was transferred to the falsework in December, 1957 and the first railway girder span was erected in January, 1958. The lift span was first operated in August, 1958 and final adjustments were made in November, 1958. Highway traffic was rerouted onto the span early in September, 1958.

Upper St. Lambert Bridge

As no traffic was involved the erection of the Upper Vertical Lift bridge at St. Lambert presented no unusual problems. With the exception of the lift span trusses, all steel up to the level of the third tier was erected with mobile or crawler cranes. To avoid the use of falsework in the lock, and for ease in riveting, the lift span trusses, weighing 55 tons each, were assembled in a horizontal position in the bottom of the lock and hoisted into place with a 75 ton pole. The erection of the upper portion of the superstructure was completed by means of a 20 ton tower derrick standing on the lift span railway deck. The approach span was erected by crawler cranes with the use of a single timber falsework bent.

Erection of the Upper Bridge started in May, 1958 and final adjustments were made in December, 1958.

Caughnawaga Bridge

A notable feature of the erection of these lift spans was the fact that

Table II. Quantities of the various components for each lift bridge.

Item No.		*Unit of Quantity*	*Lower St. Lambert*	*Upper St. Lambert*	*Caughnawaga*	*St. Louis*	*Valleyfield*
1	Structural Carbon Steel-Lift Span and Counterweights	Pound	1,077,000	1,060,000	3,429,000	2,040,200	2,287,500
2	Structural Carbon Steel-Towers	Pound	1,718,000	2,150,000	1,895,000	1,848,500	2,108,000
3	Structural Carbon Steel-Approach Spans	Pound	288,000	1,200,000	108,000	—	—
4	Low Alloy Steel	Pound	—	—	—	99,200	172,573
5	Machinery	Pound	119,300	122,000	322,400	208,200	213,200
6	Counterweight Sheave Assemblies	Pound	135,000	135,000	333,400	200,000	200,000
7	Counterweight and Operating Ropes	Pound	56,000	57,000	131,000	109,000	109,000
8	Balance Chains and Attachments	Pound	52,300	53,300	149,200	140,000	140,000
9	Scrap metal in Counterweights	Pound	1,000	1,000	78,000	10,000	10,000
10	Concrete in Counterweights	Cu. Yd.	270	260	935	540	610
11	Reinforcing Steel (in balance blocks)	Pounds	3,000	1,800	5,400	3,800	4,300
12	Main Diesel Generator Plant	H.P.	—	—	2 @ 163	285	285
13	Auxiliary Diesel Generator Plant	H.P.	—	—	2 @ 51	46	46
14	Auxiliary Gasoline Engine Drive	H.P.	75	—	—	—	—
15	Electrical Equipment	Total H.P.	308	308	2 @ 304	614	604
16	Machinery Houses	Cu. Ft.	13,500	13,500	2 @ 8,700	14,200	14,200
17	Highway Deck (open grid floor)	Sq. Ft.	8,230	14,210	—	—	—
18	Railway Deck—Steel	Pound	—	—	78,000	23,300	40,300
19	Railway Deck—Timber	Lin. Ft.	236	—	1,030	217	217
21	Road Guardrail	Lin. Ft.	950	1,900	—	2,220	2,220
22	Formed Steel Flooring—Highway	Sq. Ft.	—	—	—	4,750	6,050
23	Asphalt on Deck—Highway	Cu. Ft.	—	—	—	41	52

falsework was erected for the downstream span only. The upstream span was erected first on this falsework and then rolled into its final position, as described in detail below.

The close proximity of the existing railway line was the principal reason for the decision to build falsework for one span only. The toe of the embankment line at the level of the bottom of the channel extended into the area which would have been occupied by falsework for the upstream span. The difficulty of framing falsework on the side of the embankment, as well as the economy of erecting falsework in one position only, led to the decision to false work the downstream span only.

The falsework consisted of six timber bents 77 ft. high at 53 ft. 8 in. centres supporting the floorbeams at the bottom-chord splices of the span, and founded on concrete pads at the bottom of the channel. Four steel beams between each pair of bents supported the intermediate panel points.

In general, all steel for approach spans, towers up to the top chord level, and lift spans was done either with crawler cranes or with a 40 ton locomotive crane operating on the track. The south approach girders were erected as soon as piers were complete, thus giving access for the erection of the southeast tower. Erection of the southeast tower trusses, with overhead bracing omitted, gave access for the locomotive crane to the falsework. Due to the longitudinal component of the motion of the upstream span in rolling from the falsework to its final position, the southwest and northeast towers could not be started until after the translation was complete. The locomotive crane filled in the floor system and bottom chords of the upstream span starting from the south and working towards the north. Then the web members, top chords, overhead framing, and machinery were filled in working from north to south. The northwest tower and the north approach spans were erected by crawler crane independent of the lift span sequence.

When the riveting of the upstream span was substantially complete, it was ready for translation to its final position, which was 27 ft. laterally and 16 ft. 3 in. longitudinally, or a total movement of 31 ft. 6 in. Because of this skew translation it was necessary to have a separate runway for each corner of the span. Each runway consisted of four 85 lb. rails laid on timber cribbing. In order to clear the anchor bolts on the piers, it was necessary to raise the entire span about 2 ft. This was accomplished by the use of two 224 ton jacks and a short welded needle beam at each corner, thus permitting installation of the twenty wheel truck and completion of the runway.

Power for the translation was supplied by two 300 ton jacks with 4 ft. runout working against a weldment which was advanced and clamped to the rails at the end of each stroke. The horizontal movement took about 6 hours. When translation was complete, the span was jacked down onto its own pier members.

On completion of the translation operation, the downstream lift span was erected in its final position on the falsework using the same procedure as for the upstream. Simultaneously, the southwest and northeast towers were erected up to the top chord level.

All lifing for the upper portion of the towers except for the 42 ton counterweight boxes which required special rigging, was done by two 20 ton tower derricks, one standing on the pier at each end between the backlegs of the tower for each track.

Framing of timber falsework was started in July, 1957. First steel was erected in August, 1957. The upstream span was translated on December 30th, 1957. Railway traffic was diverted onto the spans early in June, 1958, and the spans were first lifted using auxiliary power early in July, 1958. Final testing was delayed until January, 1959, when 60 cycle power was available.

St. Louis and Valleyfield

As already mentioned these lift bridges took the place of two 100 ft. spans in each of the existing bridges and the towers were erected over two existing 75 ft. spans. Both bridges were close over the water level of the Beauharnois canal which made floating operations practical for taking out the old and putting in the new spans. Actually the existing spans had been floated out and in again many times as this was the only way the dredges which have been working in the canal for the past thirty years could get through.

There was railway and highway traffic to contend with on both bridges although its density was quite low. As far as the railways were concerned only freight trains used the bridges and during construction there was never more than a few hours delay. As the highway traffic was very light on the St. Louis bridge it was closed down for a period of three months except for the odd week-end. The highway traffic at Valleyfield was only delayed a few minutes at a time except the day when the new span was floated in.

The two lift spans were erected, complete with all machinery and electrical control equipment, on the north shore of the canal between the two bridges and about a mile from the Valleyfield bridge. The bank of the canal was first dredged to give enough draft for the barges to be used to float the spans and then falsework was constructed upon which the spans were erected. The two spans were placed end to end and a stiff leg derrick travelling on rails worked back and forth on top of the falsework during their construction. While the spans were nearing completion work commenced at the two bridges. First the piers were drilled for the large tower anchors. Due to the arrangement of the existing steelwork, it was only possible to complete one tower before the span was floated in. The north tower at St. Louis and the south tower at Valleyfield were erected first. Derricks mounted on creepers which travelled up the front legs of the towers were used for this work. The new lift spans were now readied for floating in. Two partially submerged barges were placed under a span at about quarter points and pumped out to raise it on blocking off the falsework. While this operation was going on, the 100 ft. spans to be removed from the bridge were being lashed together for floating out on barges. The floating out of the old spans and the floating in of the new one took approximately 6 hours at each bridge. Tugs and motor launches were used to manoeuvre the barges. Finally the south tower at St. Louis and the north towers at Valleyfield were erected. While the towers were being constructed at Valleyfield a protective covering of 12 in. x 12 in. timber was placed over the roadway and railway to prevent small objects from falling on traffic. This was not required at St. Louis as highway traffic was blocked off on working days. The centre piers which supported the old spans were not removed until after the lift spans were in operation and could be raised well clear for this operation.

Erection of the lift spans on falsework started in February and was completed in October, 1958. The first tower at each site was started during August and the spans were floated into place in October. The second tower at each site was started in November and the spans were first lifted in March, 1959.

Summary

A general idea of the relative size of these five lift bridges can be had from the foregoing descriptions and illustrations. However, in order that the reader may make a more detailed comparison the table showing quantities is included. The cost erected for the five bridges (superstructure only) was over 15 million dollars.

It was not the author's intention to go into a great deal of detail in this paper but to give enough information so that a good general knowledge of the bridges would be available to anyone interested.

The building of these bridges was carried out under the jurisdiction of Messrs. A. G. Murphy, Chief Engineer; S. Hairsine, Electrical and Mechanical Engineer; and R. W. Willis, Chief Structural Engineer; all of the St. Lawrence Seaway Authority: Mr. R. H. Findlay, Consulting Mechanical Engineer, to both the Seaway Authority and the Dominion Bridge Co. Ltd.: Messrs. C. A. Colpitts, Chief Engineer, Canadian Pacific Railway; A. C. Johnston, Chief Engineer, Canadian National Railways; and F. H. Simpson, former Chief Engineer and C. E. Defendor, Chief Engineer, New York Central Railroad; and their respective engineering staffs. Their considerate advice was very much appreciated by all contractors.

The author wishes to acknowledge the special debt he owes to Messrs. H. W. Buzzell, J. Smith, S. A. Craig, and H. D. Kennedy, all of the Dominion Bridge Co., Lachine, for their generous help during the preparation of this paper.

DISCUSSION

C. C. PARKIN of Toronto commented on the use of "Span-Drive" operating machinery in preference to the newer "Tower-Drive" machinery. He thought that, for the longer spans, "Tower-Drive" machinery would offset higher initial costs by greater operating economies. He also asked why the stand-by machinery for several bridges was designed to operate at half normal speed.

The author replied that initial economy studies had indicated that the "break-even" point between "span-drive" and "Tower-Drive" occurred at a span length of about 400 ft. It was the author's opinion that the trend is back to "span-drive" for economic reasons, except for very long spans. In reply to the question on stand-by bridge operation, he pointed out that modern power sources are very reliable and emergencies seldom happen. However, when they do, the location of the bridges in question are over open reaches of canal where traffic delays of short duration are not liable to be one of economie compromise.

W. G. Swan of Vancouver discussed the economics of "span-drive" as against "Tower-drive", and pointed out that tower mounted machinery becomes more competitive for lower lifts, where problems of "skew" and "cant" of the lift span becomes less critical. He also pointed out that there is a generous safety factor to prevent slippage of the wire ropes on the sheaves for "tower-drive" which is a friction type drive. Insofar as actual design was concerned, he pointed out the very large friction forces of approximately 50% of the total power requirement resulting from the use of phosphor bronze plain bearings on the sheaves instead of anti-friction bearings.

The author referred to difficulties in keeping the end floor beams level with friction drive, and the need for special error adjusting couplings to remedy this defect. He admitted that there had been a great deal of controversy about plain bearings versus anti-friction bearings, but stated that there was a large difference in initial cost and that in practice power savings would be less than one would expect. He referred to the actual operating costs of the C.N.R. Lachine Canal lift spans, which use anti-friction bearings to illustrate this point. He also pointed out that plain sheaf bearings are self healing, whereas anti-friction bearings are not.

W. H. M. Laughlin commented on the welding of sheaves, and asked if special techniques had been used. He also commended the erection engineers for the successful application of a number of ingenius methods.

The author replied that the welding procedures used to fabricate the counterweight sheaves was similar to that used by any large weldment of comparable size. He added, in reply to a question from Mr. Laughlin, that there had been slightly over 260 drawings of various types for each bridge.

S. Hairsine of Montreal discussed the basic design and said that proven features of older bridges on the Welland Canal and elsewhere had been retained, with new innovations being added as refinements rather than as radical departures. He pointed out that manual control had been retained for most part with optional automatic control to slow the span and creep it into the final limits of travel both raising and lowering. He also pointed out that the emergency power equipment was diesel powered rather than gasoline powered and that some compromise had been made between operating requirements and economic consideration in each case.

OIL TANK SITES PRELOADED BY WELL POINT SYSTEM

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When a soil investigation showed the existence of poor subsoil conditions at the Fort William Marketing Plant of Imperial Oil Limited consideration was given to several different types of foundation for the support of large oil tanks. The most economical was found to consist of preloading the ground by a combination of lowering of the water table by means of well points and fill surcharge. A well point system and surcharge were installed at each of the two tanks to be constructed in 1958, and fill surcharge only placed at two further tanks to be constructed in 1959. In two and one-half months of operation the combined loads on the underlying clay layers resulted in a settlement of over one foot out of a total predicted movement of two and one-half feet. The article describes the installation and the results which were obtained.

Description of Site

AT FORT WILLIAM, Ontario, several bulk oil and gasoline storage tanks with diameters ranging from 100 to 134 ft. are to be built, together with associated warehousing, pumping and distribution office facilities.

In the past the tanks which now exist at the site were constructed on top of piles driven to a depth of 40 to 50 ft. in the underlying soil. Notwithstanding the pile foundation, settlements have taken place under these tanks, the floors of which in some instances are badly rippled. No record is on hand of any borings which may have taken place in order to determine the soil conditions for construction of existing tanks.

When the new expansion was being planned, a soil investigation was carried out with the following results.

The site, as shown in Fig. 1, which is a photograph taken prior to construction operations, is level but is only one or two feet above the elevation of adjacent Lake Superior. Areas in which it is proposed to carry out future tank construction are mostly covered with fairly dense bush 5 to 6 ft. in height. From the general appearance of the site and previous experience at similar locations in the Lakehead area, it was felt that the subsoil would be composed of normally consolidated post-glacial lacustrine sediments, probably in the form of varved clay. The investigation confirmed this opinion.

From the ground surface to a depth of approximately 24 ft. the soil uniformly consists of a sandy silt or silty sand containing a few thin layers of a silty clay. This soil is underlain to a depth of about 75 ft. by varved clay deposits, the upper 15 ft. of which consist of a highly plastic dark grey clay. Below the upper layer of material was found a reddish-brown silty clay of much lower plasticity, 35 to 40 ft. in thickness. The average properties of the soil and the idealised soil profile assumed for the calculations are shown in Fig. 2 from information supplied by a number of boreholes. All boreholes were terminated at approximately 80 to 85 ft. depth in a primarily granular soil composed of a clayey sandy gravel. Information very generously supplied by the Ontario Hydro-Electric Power Commission indicated that this granular soil extends to a depth of about 130 or 140 ft. below ground surface, where bedrock is encountered.

Settlement Calculations

Consideration was first given to the most economical method of construction which would involve building the tanks directly on a normal gravel pad placed on the stripped ground surface. For the purpose of a settlement analysis, the subsoil was divided into four layers with soil properties as indicated in Fig. 2.

Since recent research has indicated that the values of relative density given by split spoon correlations are probably too low, especially near the ground surface, relative density measurements were actually carried out in the upper layer of silty sand which is cohesive enough to enable this to be done. These measurements gave a relative density of about 80% to this layer, compared to relative densities of about 40% obtained by the split spoon sampling technique.

Consolidation tests were carried out on representative samples from the two compressible clay layers and the results are summarised in two curves, shown in Fig. 3.

The possibility of complete failure of the tank must be considered first and, to this end, the ultimate bearing capacity of the underlying soil is estimated. A 134 ft. diameter, 48 ft. high tank was studied. When full of water (the normal testing procedure), the bearing pressure underneath the base of such a tank will be approximately 3000 lb. per sq. ft. This bearing pressure will be spread out or reduced before reaching the underlying soft, plastic clay. A spread of 30° to the vertical gives a bearing pressure on the surface of the clay layer of approximately 2300 lb. per sq. ft. Current soil mechanics literature indicates that the ultimate bearing capacity of a large circular footing on soft clay is approximately equal to 6 times the cohesive shear strength of the clay. With a cohesive strength of 500 lb. per sq. ft., the ultimate capacity of the upper clay layer is computed conservatively to be 3000 lb. per sq. ft. Consequently the factor of safety against complete failure of the underlying soil is computed to be at least equal to 3000/2300 or about 1.3, based on the shearing strength determined in the field vane measurements.

In spite of the conservative nature of the assumptions on which the analysis was based, it was felt that such a factor of safety was sufficiently low to require a reduction in height of the proposed tanks from 48 ft. to 40 ft.

The subsoil in its present condition is in a state of equilibrium under existing overburden pressures only, and any additional load such as an oil tank will certainly cause the soil to compress and consolidate. This compression will take the form of instantaneous elastic and plastic movements of the silty sand layer, and elastic plastic, and time consolidation settlements in the underlying clay and silty clay layers. Calculations of the settlement amounts due to each of these causes were carried out for a 40 ft. high tank, filled with water, although actual settlements would of course be due to varying levels of product.

From previous experience and the measurements of the relative soil density of the silty sand, it was concluded that settlement due to elastic and plastic effects in the sand layer would amount to about 3 or 4 in. The amount of settlement due to the immediate deformation of the underlying clay layers was calculated from the properties of the clay, as evidenced in the laboratory tests. The computations indicated that the plastic and elastic settlement of all the underlying clay layers would be of the order of 5 in., most of which would take place in the highly plastic upper clay layer.

The remaining settlement would take place over a long time as the result of the consolidation of the clay and silty clay. Calculations based on laboratory consolidation tests indicated that consolidation would yield a total settlement taking place over a period of years of about 1.8 ft. Thus, an immediate settlement due to compression of the upper layer of sand and to movements in the clay under

Fig. 1. View of general area of site before commencement of foundation preparations.

Fig. 2. Profile of soil obtained from several boreholes, showing average properties attributed to each layer for analysis purposes.

Depth, ft.		*Soil Type*	*Thickness of Layer, ft.*	*Moisture Content %*	*Wet Unit Weight lb./cub. ft.*	*Field Vane Shearing Strength lb./sq. ft.*	*Consolidation Characteristics*
0	0						
	1	—Water level—					
10							
		Sandy silt	24	23	125		
20							
	24					500	Compression Index 0.37 Initial Void Ratio 1.38
30							
		Varved clay	15	60	102		
	39					600	Coefficient of
40						1000	Consolidation 0.6 ft.²/day
50							Coefficient of Consolidation 0.6 ft.²/day
		Varved silty clay	38	30	120	1300	Compression Index 0.17 Initial Void Ratio 0.78
60							
70							
						1700	
	77						
80							
		Clayey sandy gravel		10			
90							
100							

the tank, would amount to approximately 8 or 9 in., while the consolidation of the underlying clay layers would add 1.8 ft., leading to a total movement of about 2.6 or 2.7 ft. Because of the uniformity of soil conditions encountered in the various boreholes, it was felt that there would be a very good chance of this settlement occurring uniformly under each tank.

The lower than customary factor of safety (even of a 40 ft. high tank) and the large settlements expected made it undesirable to construct the tanks directly on a pad on the ground surface. Accordingly, cost estimates were prepared of the various methods of building suitable tank foundations. From these cost considerations and because of the uncertainty inevitably associated with the behaviour of soil under superimposed loading, careful thought was given to the possibility of preparing the site by preloading. Preloading is now a familiar way of preparing poor sites since several accounts have been given of the method in which large amounts of fill were placed on the foundation area, in order to induce settlement before the erection of the proposed final structure. The consolidation which takes place under the preloading has also the effect of increasing the shear strength of the underlying soil.

As the result of this consideration, the author recommended that the soil at the site be preloaded in two ways: by placing a layer of fill on top of the stripped natural ground, and by installing a ring of well points around each of the two areas to be occupied by future tanks. Since these recommendations were adopted, a fuller description of the well point preloading system is given in the next section.

Preloading

The effect of well points or wells in causing settlements to adjacent buildings during construction operations has frequently been noticed in the past. These settlements have led to considerable damage in many cases and are a great inconvenience during construction. The lowering of the water table changes the effective weight of the soil through which the water table is lowered from its buoyant unit weight to its normal wet unit weight. Thus, the effective stress imposed on the underlying soil layers is increased by 62.4 lb. per sq. ft. for every foot that the water table is lowered. If the underlying soil is a compressible material, such as in the present circumstances, consolidation and surface settlements will ensue.

At the Fort William site the lowering of the water table a distance of approximately 20 ft. would impose an additional stress on the underlying clay layers of approximately 1250 lb. per sq. ft.

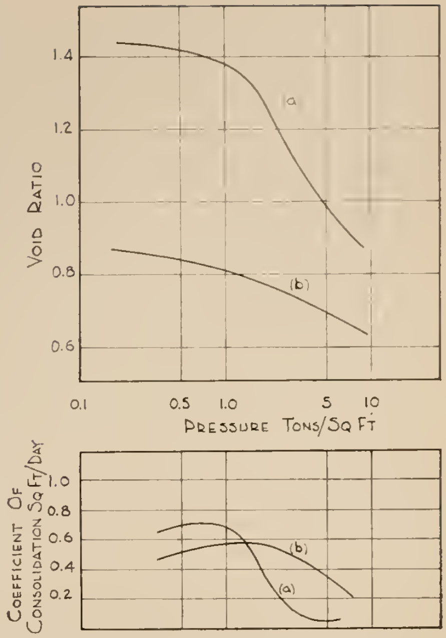
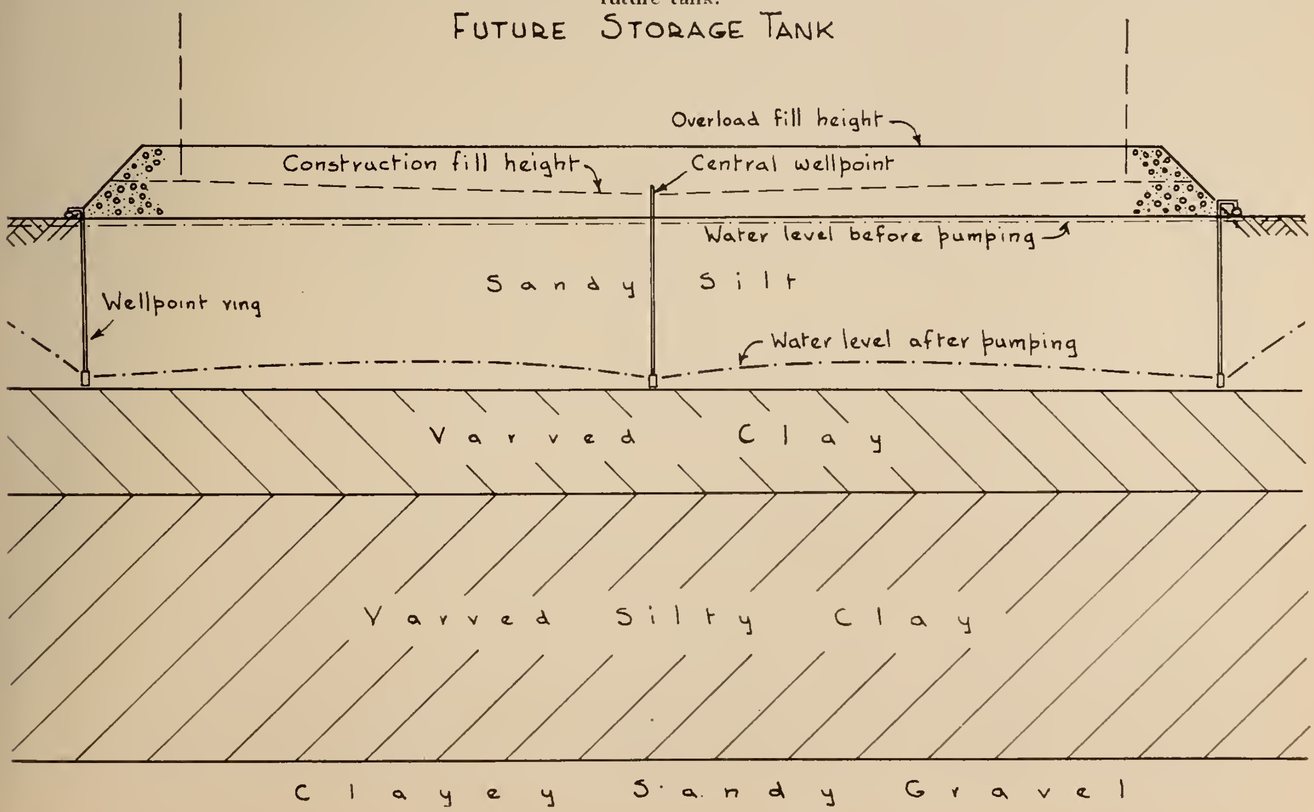


Fig. 3. Average consolidation characteristics of the two principal clay layers.

In addition to the actual settlement achieved, the information supplied on the properties of the soil during consolidation and on the nature and type of settling which the soil underwent, would be of value

Fig. 4. Diagram showing soil profile graphically together with approximate layout of wellpoints and their relation to the future tank.



in the erection of all the other oil tanks in the area and would enable specific recommendations to be made in future regarding their construction, filling, and maintenance.

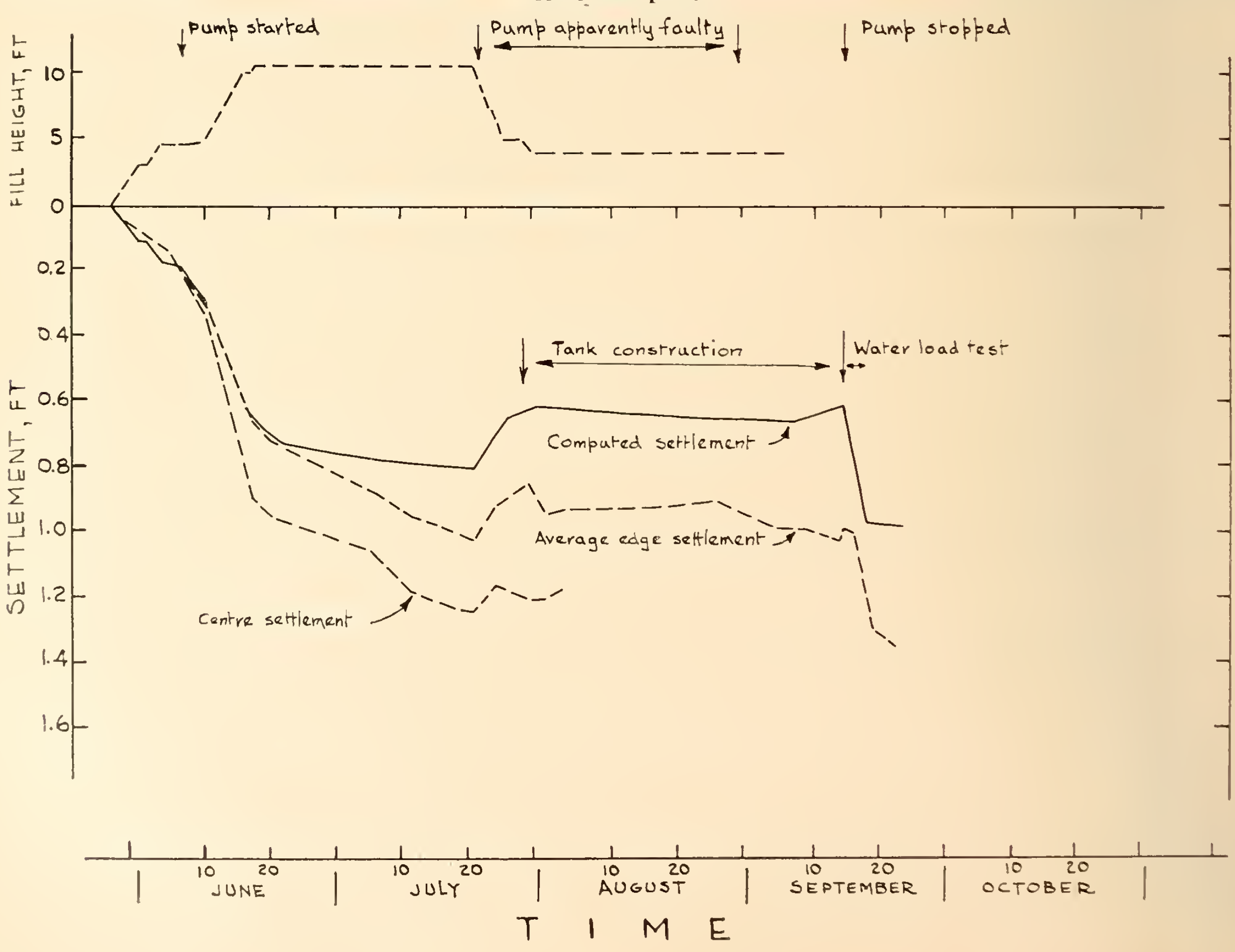
Compared to preloading by fill, the well point system has the advantages of flexibility and ease of installation, operation, and removal. The marshy conditions at the site would also be improved by the drainage.

A trial installation of about 12 well points was set up around the middle of May, 1958, for the purpose of ascertaining the feasibility of draining the fine-grained sandy silt layer. When they proved to be successful, two complete rings of points around 100 and 134 ft. diameter tanks were installed under the author's supervision. The system was set in operation at the larger of the two tanks on 6 June, 1958, and at the smaller tank on 13 June, 1958. Fig. 4 is a drawing of the layout of the well points at one of the sites and the actual installation is shown in Fig. 5.

It had proved possible to obtain substantial quantities of good quality fill material locally, and the filling work proceeded at alternate sites as the well points were installed. The site was first of all stripped of the surface layer of approximately 1 ft. of organic matter and vegetation, and a 6 in. to 1 ft. thick sand pad placed on the surface. On top of the sand pad five settlement plates at each site were located, four at the cardinal points of the compass, and one in the centre of the tank area.

Fig. 5. Filling operations in progress at larger of two tanks. Part of wellpoint installation can be seen in left foreground. Pipe sticking out of fill is one of the settlement points.

Fig. 6. Plot of the settlement of the large tank versus time. The solid line shows computed settlements based on average soil properties and one dimensional consolidation; the dashed lines show actual settlements given by the four edge and one centre settlement point.



Zero readings were established at these settlement points and fill was raised to a height of 10 ft. at each site by 18 June, 1958.

Results of Preloading

The calculations of preloading settlement expected were based on the soil properties measured during the consolidation test, and this requires a brief discussion.

The laboratory consolidation test is carried out on laterally confined samples to which the load is applied at right angles to the direction of layering of the soil. Porous stones are supplied above and below the sample, which allow the water to be squeezed out of the soil in a vertical direction. The calculations of the time which any particular degree of consolidation may be expected to take are based, therefore, on the permeability of the soil at right angles to the soil layers or varves in the present case. However, in the natural soil the application of the load at the surface of the ground may be expected to expel water from the voids of the clay both vertically and horizontally. It is difficult to take this into account in settlement calculations. Therefore, the estimates are based on vertical drainage only and on those properties of the soil obtained from the vertically drained laboratory consolidation tests. It has been found that the final amount of settlement can be predicted with reasonable accuracy by these methods, although the time predictions are generally incorrect.

In the present case, computations based on the laboratory properties of the soil indicated that 6 to 9 in. of total settlement might be expected in 3 months of preloading. Considering the natural three-dimensional process, it was therefore felt, with a certain amount of confidence, that the actually occurring settlements would probably exceed 1 ft. in a 3 month period.

Settlements were measured approximately twice a week at the various settlement points at both tanks, from the beginning of filling and well pointing operations. Fig. 6 is a plot showing the various stages of filling, the initiation of well point operation and the progress of settlements at one tank site. For comparison on this diagram, the computed average settlement curve for the actually observed load application is shown. It will be seen from this figure that the estimate of the elastic and plastic behaviour of the soil was apparently very nearly correct, but that the amount of movement attributable to consolidation proceeded, as expected, at a more rapid rate than theory predicts.

Fig. 7. View of site near completion of construction of new tanks, in middle distance. Between tanks and at extreme right of photograph can be seen preloading fill for two tanks to be constructed in 1959. The wellpoints have been discontinued at the larger of the two tanks and water can be seen at the ground surface.

To such a degree did the increased settlement occur, that a careful scrutiny of the movements at the middle of July, 1958, indicated that it would be possible to begin removing the surcharge fill at the beginning of August, 1958, so that construction of the tanks could be got under way by 15 August instead of 15 September, 1958, which was the date originally recommended. This was carried through and fill at both sites was removed to leave approximately 4 ft. thick gravel pads (the extra thickness being left to allow for future settlements) by the end of July, 1958. The fill removed was added to fill already placed at future tank sites which will be preloaded by the fill only for a period of approximately one year. Construction of the tanks proceeded and the final condition of the site at the end of construction is seen in Fig. 7.

From the behaviour of the tanks during the preloading process a curve was predicted and plotted for the progress of settlement as it should occur during the water load test. One such prediction was made for each of the two tanks constructed since the preloading had indicated slight differences between them.

Settlement observations were taken three times a day during the process of filling the tanks with water, which occupied four days for the larger of the two tanks and two days in the case of the smaller. The results of the water test agreed very well with predicted settlement values and were considered eminently satisfactory. As a result of the behaviour of the tanks during the preloading process and during the water test, predictions have been supplied regarding the probable future behaviour of the tanks when loaded with final product. The best estimate that can be made at present is that each of the two tanks will settle about 0.3 ft. immediately on filling and about another 0.6 or 0.7 ft. in the next year after filling. This amount of movement may be compared with originally predicted settlements of about 2.6 or 2.7 ft. total for each tank.

On the basis of preloading behaviour the smaller of the two tanks may be expected to settle differentially about three inches across the diameter of the tank in a determined direction. The future behaviour of the two other sites which have been preloaded by the application of fill only has also been worked out and information regarding future movements has been supplied.

Acknowledgments

The wholehearted co-operation of all Imperial Oil engineers concerned with this project, in particular Mr. L. Grime of the Toronto Office and Mr. L. Haberman of the Winnipeg Office, the Site Engineer, is acknowledged with appreciation. The success of the well point installation is due in part to the efforts of Mr. H. Ruddy and Mr. G. B. Wheeler of George W. Crothers Limited in Toronto.

The original soil report incorporating stability and settlement calculations was written by Mr. B. F. Welsh, while later computations were checked by Mr. J. J. Schoustra, both of Racey, MacCallum and Associates.

PROCESSING OF LOW-GRADE IRON ORE USING PETROLEUM AND NATURAL GAS

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THE NECESSARY foundation for industrializing any country is a basic steel industry. Canada is in the midst of changing from an agricultural to an industrial economy. The Canadian iron and steel industry has developed tremendously in the last twenty years, and will continue to do so.

The basic requirements for steel production are iron ore and metallurgical coke. The industrial heart of Canada lies in southern Ontario and Quebec. In this area, there was no Canadian iron ore, or Canadian metallurgical coke, available twenty years ago. The Dominion Steel & Coal Co. operations in Sydney, Nova Scotia, were based on local coal and iron ore from Newfoundland. Apart from this operation, all steel produced in Canada twenty years ago was made from imported American coal.

The recent discovery and exploitation of very large iron ore deposits in Canada has made available in Canada huge tonnages of iron ore. The production from presently operating Canadian iron ore mines is many times greater than can be utilized by the Canadian steel industry. Steel production in Canada is determined by the markets for steel in Canada which are dependent on the size of the population in Canada. The Canadian steel industry will grow vigorously as the population of this country grows. The excess iron ore, which can be produced above that useable in Canada, will be and should be exported from this country.

It is obvious that Canadian organizations should thoroughly investigate all possibilities of exporting Canadian iron ore in the most profitable form. If it is possible, profitably, to partially process iron ore to metal in Canada before export, this should be done. The primary requisite for such a plan is a market for the partially processed product. A second necessary factor in the study of such possibilities is the existence of commercially proven processes for producing metal from iron ores using fuels available in Canada.

New Technical Developments

Two major technological advances affect the present situation in Canada.

1) *Iron Ore Concentration.* It has been conclusively demonstrated on a very large commercial scale that low-grade iron ores of certain types can be ground, magnetically concentrated, agglomerated by sintering or pelletizing, and sold at a profit.

In the concentration of low-grade iron ores, there are several techniques in use for obtaining a rich, fine, concentrate of iron oxide. This fine material cannot be fed to the standard blast furnace, but must be agglomerated by sintering or pelletizing. These processes consist in heating the fine material to a point just below the fusion temperature, about 2,200°F. In the sintering process, a bed of fine material is fused into sinter which has the appearance of clinkers left after burning coal. In the pelletizing process, the fine concentrate is rolled into small balls and then heated.

There is no major application of oil or gas fuels in the sintering process except for ignition of the bed, which contains sufficient coke to support combustion.

In the pelletizing process, oil or gas can be used as a heating fuel. Fuel consumption in the pelletizing process ranges from about 500,000 B.t.u. per ton of pellets produced to a maximum of about 850,000 B.t.u.

The problem of concentration of magnetic low-grade ores which consist of magnetite crystals in waste rock, is relatively simple.

Where the iron oxide occurs wholly or partly as hematite, there are several methods of recovering the hematite. Probably the most dependable process is to convert the hematite to magnetite and then recover the iron oxide by magnetic separation. The feasibility of this procedure depends strongly on the price of available fuels. To heat the ore to reaction temperature of between 1,200°F and 1,500°F, and to provide suitable gas for reducing hematite to magnetite, requires the supply of between 450,000 B.t.u. and 1,500,000 B.t.u., depending on the type of fuel used and the process and equipment chosen to carry out this magnetizing roast.

2) *Direct Reduction.* It has been conclusively demonstrated on a large commercial scale that iron metal can be produced directly from iron ore without the use of metallurgical coke. Natural gas, oil, and electric power can be substituted for metallurgical coke. The resulting iron metal can be sold at a profit to steel making plants if the price of these fuels is sufficiently low. The market for such metal is small and uncertain at present.

Direct reduction of iron ore to metal is carried out by heating the iron ore, which is a mixture of oxides of iron, to a temperature of about 2,000°F and then contacting it with hot reducing gas. The reducing gas, which is carbon monoxide or hydrogen, or a mixture of the two, removes the oxygen from the iron oxides, leaving metallic iron. The rate of this reaction depends on several factors. The higher the temperature and pressure, the richer the reducing gas in carbon monoxide and hydrogen, the greater the rate of supply of gas to the ore, and the greater the surface area of ore exposed to the gas, the faster will be the speed of reaction.

A large number of direct reduction or sponge iron processes have been developed. Only a few of these have reached commercial production. The fuel requirements for the more interesting and practical of these processes are listed in Table I.

Reduction can be carried out at low temperature, in which case the metal is obtained in sponge form and is not melted. Alternatively, the process can be carried out at much higher temperatures, in which case molten metal is produced.

For true comparison of fuel requirements of the first type of process, the energy required to obtain metal in the same state must be determined. This means that, if solid sponge iron is produced, it should be melted and carried through to molten iron, which can be cast into pigs for true comparison to the fuel requirements for producing such products as pig iron from blast furnace.

In order to describe and compare the more interesting and commercially proven processes, they can be classified as follows:

Bases for Comparison of Processes

The processes to be considered can be classified as follows:

1. Standard Recognized Methods—blast furnace, electric pig iron furnace.
2. Commercially Proven Processes—HYL, R-N, Krupp-Renn, Tunnel Kiln.
3. Pilot Development — H-Iron, Strategic-Udy.
4. Initial Stages of Development—Jet-smelter, cyclosteel process, McDowell process, Esso-Little process, U.S. Steel Nulron process.

Plant and production costs for Class 1 processes are known and predictable on the basis of past performance of existing plants. Class 2 processes are sufficiently proven so that reliable plant cost estimates and production cost estimates can be made. Class 3 processes are under development and plant costs and production costs provided by the organizations concerned are not proven. Class 4 processes are not worth detailed economic studies at the present time, since no reliable plant costs or production costs can be provided.

Fuel Requirements

The major difference between the processes under study is in the type, amount, and cost of fuel and power required to carry out reduction of iron ore. For plants fed with the same grade of iron ore and making the same products, the only differences in production costs that are possible are due to differences in prices of suitable iron ores and of fuels and power. Differences in other items of cost of plant operation will make only minor differences in the final cost of the product.

Table I

Approximate Fuel Requirements of Processes Operating on 65% FE Pellets

NB—All processes producing cast pigs from molten metal. Melting of sponge iron in special electric arc furnaces required 400 KWH = 1,360,000 BTU

Process	*Type of Fuel and MM BTU Equivalent*				*BTU Consumption Millions*	
	Carbon	*Oil*	*Natural Gas*	*Electricity*	*Gross*	*Net**
Blast Furnace	20.3	—	—	0.03	20.3	14.5
Electric Pig Iron	13.0	—	—	7.6	20.6	16.0
Strategic-Udy Koppers	12.6	—	—	4.9	—	17.5
H-Iron—oil	—	20.0	—	1.92	—	22.0
—gas	—	—	16.24	1.8	—	18.0
Tunnel Kiln	17.5	3.3	—	1.66	22.4	21.0
H.Y.L.—oil	—	26.4	—	2.68	29.0	22.3
—gas	—	—	18.7	1.36	20.1	16.2
Wiberg—oil	0.13	29.7	—	1.36	31.0	23.0
—coke and oil	3.04	2.0	—	4.48	—	9.5
—coke and gas	2.50	—	1.55	4.26	—	8.26
R-N	25.0	—	—	1.66	26.6	25.2

*—After fuel credits for excess gas from the process.

Descriptions of Processes

Only the essential features distinguishing processes from one another will be described.

A. Processes Producing Pig Iron

Blast Furnace—In the well known blast furnace, iron ore is charged to a large shaft furnace along with the required coke and limestone for smelting the ore and slagging off impurities. Molten metal may be cast into pigs of *pig iron* which has a high carbon content of over 3%.

Electric Pig Iron Furnace—The Tysland-Hole furnace is now a well proven and standard process with special application where electric power is low in price and the market to be satisfied is about 500 tons of iron per day. In effect, part of the coke used in the blast furnace is replaced by electrical energy to provide the required energy necessary to smelt iron ore in any furnace, or combination of furnaces. Less coke is therefore used per ton produced and this may be a weaker and poorer grade of coke because the bed of ore in the furnace is not nearly so deep as in the standard blast furnace. The molten metal produced is similar to the product from the blast furnace and can be cast into pigs of iron in the same way. The rich exhaust gas from the furnace can be used as fuel and credited to the smelting process.

B. Processes Producing Low Carbon Iron

Direct reduction processes produce sponge iron. In order to be easily marketable at a high price, it is recommended that sponge iron be melted in auxiliary furnaces to produce low carbon iron at under 1% carbon and then cast into small pigs of metal. This metal would contain less than .02% each of all other elements in the preferred specification. Such a high purity product cast into small pigs weighing 5 to 7 lb. has been christened *Canadian Iron.*

This product can be produced by melting sponge iron, if special electric arc melting furnaces are added to the plant and fed with sponge iron along with carbon and slagging additions to make a low carbon molten metal which could be tapped intermittently. No attempt is made in the furnace to refine the iron to make steel. The product is intended for remelting and refining in steel-making furnaces.

In cases where the sponge iron produced by the direct reduction process contains more than 5% silica, i.e., when pellets or ore are used, it is preferable to crush and grind and magnetically concentrate the sponge iron before melting. The preferred maximum silica content for sponge iron to be melted is 2%.

A special process under this classification is the Krupp-Renn rotary kiln process. The product is liquid metal which solidifies in small pellets and can be marketed in the form of low carbon iron nodules or luppen.

In this process, low-grade high-silica ore, which is not amenable to concentration by other methods, can be fed to the kiln along with fine coal and sufficient limestone to provide the special acid slag required for the process. The iron ore is reduced and the silica slagged off. The metal becomes liquid but the slag remains a thick, viscous mass in which the iron is suspended. When discharged from the kiln, the slag containing the luppen is crushed and the luppen recovered magnetically. Due to the reduction conditions in the Krupp-Renn kiln, the iron luppen are high in sulphur which enters the iron from the coal. Except in most unusual cases, the luppen cannot be considered as feed for steel-making furnaces, but are used as feed for blast furnaces. The intended application of the Krupp-Renn process is therefore as pyrometallurgical ore-dressing process for lean high-silica ore.

C. Processes Producing Iron Briquettes

Direct reduction processes produce sponge iron which can be crushed, if necessary, then ground and magnetically concentrated to produce a fine iron powder preferably containing at least 95% total iron and less than 1% silica. This fine iron powder with no binder added can be compressed in a hydraulic ram to produce briquettes of iron with a relatively high density of between 5 and 6. Fine carbon can be added to the iron powder before briquetting to give a desired carbon content in the resulting briquette.

D. Direct Reduction Processes Making Sponge Iron

As explained previously, it is not recommended that sponge iron be sold as produced but that it be further processed by briquetting or preferably by melting and casting into pigs.

HYL Process—This process has been in commercial operation for three years at Monterrey, Mexico, producing 200 tons per day of iron. The unit under construction will produce a further 500 tons per day of iron. Four reaction vessels are provided. This is a batch process. The vessel is loaded with iron ore, pellets or sinter, closed with a gas-tight top, and then hot gas is passed through it to raise it to reduction temperature and to begin reduction into metallic iron. After the initial stages of reduction, the flow of reducing gas is changed so that gas from the next vessel, which is now the primary reduction vessel, passes through the partially reduced ore. When reduction is complete, the gas flow is again changed so that fresh, cold, reducing gas enters the vessel which now contains hot sponge iron. The sensible heat in the sponge iron is used to pre-heat the reducing gas which goes to primary reduction. The fourth stage of the process consists of emptying the vessel of the batch of cold sponge iron and reloading it with fresh ore. With four vessels, each holding 105 tons of ore, production is 500 tons of metal per day when using a rich pellet.

Reducing gas is supplied in the present plants by reforming hot natural gas over a nickel catalyst with high pressure steam. A satisfactory reducing gas can also be made by partial combustion of naphtha with oxygen followed by reforming of the gas with steam. Provision of the required reducing gas from oil is considerably more expensive than the production of gas from natural gas at an equivalent price per million B.t.u.'s.

A 150,000-ton per year plant, with four vessels, is considered as a unit, since four vessels are necessary for an efficient cycle.

Wiberg-Soderfors Process — This direct reduction process has been in use for over fifteen years in Sweden in commercial production. There are now seven furnaces in operation, the largest of which produce about 50 tons per day of metallic iron. Rich lump iron ore, pellets, or sinter are fed into the top of a shaft furnace. The descending ore meets a rising current of reducing gas at a ratio of 2 carbon monoxide to 1 hydrogen. Hot gas entering the bottom of the shaft performs final reduction. Partway up the shaft, three-quarters of the gas is removed from the shaft and recycled through an electrically heated carburetor containing coke. The remainder of the gas continues on up the shaft to perform pre-reduction and preheating of the ore. The recycled gas is brought back up to reaction temperature and CO_2 and H_2O are converted back to carbon monoxide and hydrogen in the carburetor. This technically excellent method gives the lowest fuel consumption of any direct reduction process.

The process can also be operated by making the reducing gas by partial oxidation of fuel oil, followed by passing the resulting gases over a bed of hot coke. When this plan is followed, the real technical advantage of the Wiberg-Soderfors process is lost. The proper location of this process is in areas having very cheap electric power. The price of fuel oil would have to be extremely low to make the process economically feasible when based on fuel oil.

The R-N Process—This process has been developed by Republic Steel and National Lead Corporations and has been in pilot commercial operation in Alabama for over two years. Minus half inch or finer iron ore is fed to the kiln, along with coal having a controlled percentage of volatiles and limestone to pick up sulphur and phosphorus. The kiln is fired with gas or oil and there are air inlets along the length of the kiln to control combustion throughout the length of the kiln. Excellent control of gas composition and temperature is obtained. Temperature is sufficiently low so that no slagging or melting of the gangue or iron takes place. The discharged mixture of limestone, coke, and sponge iron is crushed and magnetically separated.

Coals with exactly the right specifications are rare so that in most cases it is necessary to provide a char plant to give a reactive char with the right percentage of volatiles.

Tunnel Kiln Process—This method is included mainly for comparative purposes and for future reference. The method of packing iron ore along with coke and limestone in a sealed ceramic container or *sagger* and then passing it through a brick kiln has been in successful commercial use for producing iron powder for many years. Although the plant cost is very low, the labour requirements are very high. When the plant is mechanized to cut down on labour requirements as at Oxelosund, Sweden, the plant cost is no longer very low.

H-Iron Process—Although this process is still in the early pilot development stage, it is included because it is designed to treat fine concentrates without pelletizing or sintering. The fine concentrate is fed to a pressurized vessel where a fluidized bed is maintained by a flow of reducing gas high in hydrogen at about 500 pounds per square inch and 900°F (480°C). The gas is recycled, water vapour removed, and fresh hydrogen added to the gas stream. Reducing gas may be produced from fuel oil by partial oxidation and subsequent treatment.

The first commercial unit for 50 tons per day of iron powder will be operating shortly at the plant of a certain steel company. It appears likely that the capacity of this plant which will produce iron powder will not be as high as it would be if it produced sponge iron. Operation of this unit should prove whether or not fine sponge iron can be produced from a fluidized bed of fine iron ore concentrates on a commercial scale.

Strategic-Udy-Koppers Process — This process, which is also an initial pilot operation, is a modification of the electric smelter technique. The exhaust gas arising from smelting of an ore-coke mixture is passed through a rotary kiln where it performs pre-reduction of the ore. The hot partially reduced ore is charged to a special type of electric smelting furnace. The entering charge is therefore at about 1,700°F (925°C) and is reduced to some desired extent. Power consumption in the electric smelting furnace is therefore less than in the standard electric smelting furnace. In addition, the furnace is not run with a submerged arc which results in somewhat different smelting conditions.

From experience with electric pig-iron furnaces in the past, it seems probable that the maximum degree of pre-reduction that will prove profitable and technically feasible is about 30% on a rich ore. This is estimated to give a power consumption of 1,400 kwh. per ton of iron, according to the company's own figures. On a lean ore, pre-reduction may be as high as 50% without undue technical difficulties or excessive cost in pre-reduction.

As stated before, the major differences between the processes studies lie in the fuel requirements. Table I shows the approximate fuel requirements of these processes when operated on 65% Fe pellets. Total heat requirements to produce a final produce in the form of cast pigs from molten metal are included. Compared on the basis of net B.t.u. consumption, the blast furnace provides a convenient yardstick while the net consumptions of the *Strategic-Udy Koppers* and *H-Iron* processes must be looked at as preliminary estimates based on the first stages of pilot operations.

It is interesting to compare the production costs of all these processes on the same basis and for the minimum profitable plant size.

Assuming that the same iron ore is used in all cases, and that the required plant to produce 150,000 tons per year of molten iron is provided in all cases, then the approximate cost of producing one gross (or metric) tons of iron will be:

1. Iron Ore Required	about $25.00
2. Fuel and Power—see Table I	—
3. *Cost of all other materials plus labour, supervision, repairs, and maintenance $19-21.50 (say)	$20.00
4. Capital charges, depreciation, etc. at 15% $10-12.00 (say)	$11.00
5. Cost of production above fuel cost	about $56.00

except in the case of the 300,000 ton per year blast furnace, where Item 3 will be approximately $12.00, and Item 5 about $48.00.

To this approximate cost, the local cost of the required quantity of fuel for the process as shown in Table I must be added to give the total production cost.

These costs are not meant to be exact, but are approximately correct. Even relatively major changes in the cost and quantities of the material and services required will not result in any major change in these processing costs. The only major variable in the total costs is the cost of suitable fuel.

The cost of sponge iron from the direct reduction processes will be about $20.00 below these costs for molten iron.

Conclusions

The cost of the required plant to produce molten iron from iron ore by any of these direct reduction methods is higher than the cost of a present day blast furnace operating in the cost efficient, modern, manner possible.

It is also evident that the cost per ton of molten iron made by any of these processes is higher than the cost of blast furnace pig iron when the blast furnace is located in a large market area where coal is relatively cheap.

Neither of these observations are at all surprising, but there has been a great deal of misunderstanding of the role and application of direct reduction processes, due to comparison of the production cost of sponge iron to the cost of pig iron. This is not a true or valid comparison.

The proper and profitable application of direct reduction processes is in locations where oil or gas are available at lower prices than the equivalent quantity of metallurgical coke, and where the market to be served is relatively small—at less than 1,000 tons of iron per day.

Although this condition exists in many locations in the world, the supplying of such markets under these conditions is, above all, today a Canadian problem of paramount importance.

At the present time, if rich ore, at more than 65% Fe, or an iron ore concentrate at more than 65% Fe, are available at a price of 20c per unit of iron or less and if oil or natural gas are available at 35c per million B.t.u. or less, a thorough investigation of the possibilities of direct reduction of iron ore is justified.

THE OIL AND GAS INDUSTRY

THE PETROLEUM industry may be divided into four generalized phases of operation: (1) exploration and production of crude oil and gas; (2) movement of crude materials to processing centres; (3) processing (refining) of oil and gas; (4) storage and distribution of refined products. Phases (2) and (4) involve the common factors of moving materials by pipeline or by ship, rail, and road tanker.

Instrumentation is essential to all these phases, but this article will deal particularly with the processing industry, which is among the leading users of advanced control instrumentation and recording equipment.

The specialized instruments used for the discovery and investigation of sub-surface formations, and for the logging of drilled wells are outside the scope of the present series of articles. At the other extreme of the industry, the distribution of products (except by pipeline) involves mainly conventional metering instruments.

Refining and pipeline operations will be dealt with separately.

PETROLEUM PROCESSING

The processing, or refining, of crude oil basically involves the physical and chemical separation, breakdown or synthesis of constituents to obtain the required end-products. Processes are mainly continuous and operate up to high temperatures and pressures. Furthermore, there is an increasing tendency towards the elimination of intermediate storage of products between different processes. There is thus a complex system of product streams between, for example, distillation, cracking, and reforming units, all of which must be fed at the right conditions of flow-rate, temperature, pressure, and level.

Instrumentation is therefore essential both to record and to control accurately the many process variables involved. Similar conditions prevail in the removal of impurities from natural gas in gas-processing plants, which also involve continuous chemical processes.

Reason for Instrument Installation

Though replies to a questionnaire on instrumentation in refining processes varied slightly in emphasis between individual companies, the main purpose of instruments is probably the control of process variables, with almost equal weight being given to improvement of quality, centralized supervision of operations, reduction of labour force, and economy of fuel consumption. This is to be expected, since the goal of a refinery is maximum quality with optimum efficiency, and hence an approach to completely automatic control, with a minimum of human intervention.

Uses of Instruments

As already outlined, instruments are needed in a refinery (or gas processing plant) to measure and control temperature, pressure, flow, and levels in vessels. Instruments are usually grouped in a central control room, though complex installations or those that have gradually been extended may have several control centres.

The transmission of signals from measuring instruments to the recording and control equipment is very widely done by pneumatic systems, but there is an increasing tendency to use electronic methods, which are becoming at least equally reliable and have better response and flexibility of application. This trend will probably be very marked in the future as transistor techniques are developed.

Electronic systems already have a point in their favour in Canada, particularly in the Montreal refining centre with its very cold winters, since pneumatic systems must be very carefully dried and lines frequently have to be steam or electrically traced for cold-weather operation.

Who Determines Requirements?

Replies to this question indicate that most companies with petroleum refining facilities determine their own instrument requirements, though in some cases the staff of an affiliated company may be involved. A petroleum refining company may depend on a research and development company within the overall organization for technical advice during the installation of new plant. At the same time, certain engineering companies specialize in the construction of refineries for the petroleum industry, and their advice on instrumentation may be used in some cases. Also, certain process units, such as catalytic cracking and reforming, are installed under licence from the company that developed them originally. Many specifications have to be followed closely, but there is latitude in the choice of the actual instrumentation used.

Who Buys the Instruments?

Practically all replies to this question showed that the engineering department is mainly responsible for specifying the types of instrument to be used and the source of their supply. Some of the individuals concerned may be members of the plant operating and maintenance departments. Even though the purchasing department may make the final order from a particular supplier, this is influenced by engineering recommendations.

• INSTRUMENTATION

Servicing systems

All respondents indicated that their own staffs are mainly responsible for servicing instruments, though a small proportion of service requirements may be met by independent contract or as required from outside sources. These are probably mainly concerned with specialized equipment.

Preventive Maintenance

Since continuity of operation, and particularly continuity of control of variables, are essential in the refinery the breakdown of components must be minimized. Consequently there is a tendency for most operators to use preventive maintenance programs for instruments. This is borne out by the replies to the questionnaire, though a few exceptions are recorded. Rather than repair a defect in an instrument, which may later develop a different fault, it is often preferable to remove complete units and overhaul them at leisure while replacing them with a standby unit. This is usually very convenient with electrical units which can be removed and plugged in quickly. Others, which cannot be removed without affecting the process, are maintained at regular plant shut-down periods or by pre-arrangement with operating staff if more frequent overhaul is indicated. The experience of several large operators indicates that preventive maintenance can reduce or eliminate unscheduled process interruptions, minimize replacement stocks, reduce costs, and distribute the maintenance work load evenly.

A large refinery adopted preventive maintenance for over 1450 instruments (including air regulators, large pressure gauges, etc.) at a cost of less than $500 for additional office equipment for keeping records, and carried out the program with five mechanics and a foreman. Clerical time was only six hours a week.

Spare Parts Practice

Preventive maintenance records usually indicate what spare parts are most likely to be required, so it was not unexpected to find that most companies keep a stock of spare parts based on experience. However, when starting without particular experience of certain instruments, the manufacturers' recommendations may be followed for an initial period. This does not mean that the makers' suggestions are frequently changed, since experienced refinery personnel often collaborate closely with the instrument manufacturers in the development of equipment best suited for process plant conditions.

Standard or Special Instruments

Partly because of the co-operation between operators and instrument makers, there exists a wide range of standard equipment for refining processes, and probably the great majority of instruments specified are standard models. However, experience or special requirements may call for units built to a company's own specifications or modified from standard. This specialization could possibly increase as research and development investigations into advanced process control produce new ideas in instruments. However, in the long run, the prototype special instrument of today will become another standard for the refineries of the future.

All companies who replied to the questionnaire buy their own instruments outright.

Statistics on Instrument Usage

Nearly 90 per cent of the respondents gave figures for capital investment in instrumentation. Of these, about 40 per cent indicated over $500,000, the same proportion in the range $100,000 to $500,000, and the remainder in the range $25,000 to $100,000. The same percentage of replies about capital investment in instruments during the past five years showed a range from $20,000 to $1,-500,000, the second highest reported figure being $1,250,000. Only slightly more than one-third of the companies gave figure for annual maintenance costs, and these ranged from $30,000 to $100,000.

The figures could be taken to indicate that investments in instrumentation are high in this section of the industry, but that maintenance can be relatively economical. It should be remembered that, although total refining capacity in Canada has increased rapidly in recent years, major capital investment in new or extended facilities by individual companies is not usually on a regular annual basis, but consists of a series of large steps taken over several years. Thus, a company that had no major refinery expansion in, say, five years might show a low capital investment in instruments during the period (for replacement and minor modifications), whereas another company with a smaller total investment in facilities could show a much higher investment in instruments in the corresponding period because it had added large new facilities.

PIPELINES

Although pipeline operations were not covered by the present questionnaire, they rely considerably on instruments and controls. There are now nearly 20,000 miles of main lines for transmission of oil, gas, and products across the country, with an additional 45 per cent expansion announced for the foreseeable future. This does not include the many smaller feeder lines in the fields and the rapidly growing network of gas distribution lines from main arteries to many communities.

Microwave radio provides multichannel communications for control and supervision of long lines from central dispatch points. Automatic flow-control systems, using feedback amplifier principles, are used to control unattended pumping stations. Details of products, levels, flows, motor loads, and many other variables are telemetered to control centres where they are indicated or recorded. Motors, pumps, valves, and other equipment are remotely operated and controlled from the supervisory centres.

ADVANCED CONTROL

The ultimate goal in both pipeline and processing operations is computer control. Computers have already been used for pipeline feasibility studies and the determination of optimum pipe sizes. Eventually, computers may be used for integrated control of pipeline systems.

In processing operations, one aim is to have a computer determine and maintain optimum conditions, through controls, taking into account factors such as catalyst deterioration.

Before these goals are satisfactorily reached, much remains to be done in the improvement of accuracy and sensitivity of instruments for measuring both physical and chemical variables. At present these are the limiting factors in the development of control.

Canadian Developments

NEWS OF MAJOR ENGINEERING DEVELOPMENTS IN CANADA

H. R. H. THE PRINCE PHILIP, HON. M.E.I.C ADDRESSES SCIENTISTS AND ENGINEERS

H.R.H. The Prince Philip spoke to scientists and engineers at a luncheon held in Toronto on June 29, 1959

I would like to say how much I appreciate your invitation to address you today. It would have been more appropriate, I think, if you had addressed me. Every now and then I get invitations of this sort and while I consider them a great honour I always try and get out of them in order to avoid the labour of trying to concoct something sensible to say. The course between platitudes and controversy is a rocky one, as most people who speak in public very soon find out.

However, in this particular case things are a little bit different because I think it's about time some more was said about the very solid and spectacular developments and achievements which have taken place in Canada in recent years.

There is hardly any field of science, engineering or technology in which Canada cannot show some outstanding example. Canadian medical and nuclear scientists have done and are still doing work out of all proportion to the numbers of people involved. The aeronautical engineers have fully lived up to the early courage and ingenuity of their predecessors who designed and built and Mr. McCurdy who flew the Silver Dart fifty years ago. I don't suppose any country in the world has made such phenomenal progress in the development of their natural resources, or taken such trouble to try and make the new towns which will provide the work people for these developments into satisfactory human communities.

Perhaps the most dazzling achievement of all is the cause of our present visit to Canada — the completion of the St. Lawrence Seaway for ocean going ships. There is much more to this than the very considerable engineering accomplishment. I think this project demonstrates the tenacity and strength of purpose of the Canadian character. Years of delay and frustration never discouraged and never deflected the purpose of those people who had the vision and the ambition to connect the centre of this continent to the oceans which are the commercial highways of the world.

Canada and the Commonwealth

It is this combination of technical ability with the qualities of foresight and enthusiasm which has made all these things possible. It is characteristic therefore that far from being content with commercial success at home, Canada also accepts her responsibilities as a member of the British Commonwealth of Nations.

In Feburary of this year I visited an undertaking of quite exceptional interest. At a place called Warsak in the North West Frontier Province of Pakistan a party of 150 Canadians are helping their fellow members of the Commonwealth to construct a dam 235 ft. high and 750 ft. long — a power station to produce 240,000 Kw and an irrigation system for 120,000 acres on the Kabul river. The project was initiated under the Colombo Plan and apart from the practical help in the way of technicians and experts Canada is also contributing some fifty million dollars to the project.

This is only one example in the growing pattern of inter-Commonwealth co-operation and help. It has long been recognized that the wealthy individual has a moral obligation to help those less fortunate than himself. In case this obligation should ever be forgotten most governments have established a system of taxes as a reminder.

Obligations between Nations

The same obligation is now recognized to exist between nations. It is recognized that an explosive situation will inevitably develop if the gap between the 'have' nations and the 'have-not' nations grows too big. At the moment international taxation is confined to supporting international agencies. The major work of direct assistance is done by the voluntary contribution of individual governments both in cash or in kind. Cash by itself is seldom enough. Know-how, technical skill, and experienced scientists and engineers are the means by which the well-off can help the less well-off.

But one thing further is necessary if this sort of help and co-operation is to be really effective and this point is made very clearly in the Koran where it is said "Verily, God Almighty does not improve the condition of people unless they themselves strive for it". From what I saw in Pakistan they are striving for it with a whole heart.

Looked at this way the project at Warsak is much more important than the purely civil engineering undertaking. Its real value lies in the fact that it is in essence a civil and electrical engineering university. The project is in fact providing courses of instruction for every one of the 8,000 men employed, from truck drivers to engineers, from plant managers to designers. The total value of this Canadian contribution to the improvement of conditions in Pakistan is impossible to calculate and it is certainly very much greater than the cost in pure money to Canada.

I know perfectly well that there are wonderful opportunities here, I know that there are any number of projects waiting to be tackled but it is worth remembering that the same is true of the underdeveloped countries of the world. The gap between the 'haves' and the 'have-nots' will steadily widen with catastrophic results unless the more fortunate nations singly and in co-operation make a real attempt to bring them along the path to a higher standard of living.

Many people pay lip service to the ideals of better international relations and many people seem to think that this can be achieved simply by talking. In fact much more is achieved by nations working together to complete solid, practical projects for the benefit of those who most need it. Warsak is the most convincing proof of this fact and therefore it is my hope that we shall see many more Warsaks in the years ahead.

Mr. Chairman, I am most grateful for the opportunity to pay tribute to Canadian science and engineering. I wish you every success in your future undertakings.

South Saskatchewan River Project

Everything involved in the construction of the South Saskatchewan River Project is big. The dam will be the largest rolled-earth fill dam of its kind in Canada and one of the larger ones in the world. It will rise above the present floor of the river 210 feet and will stretch across the river valley for a distance of almost three miles.

The diversion works associated with the dam to contain the flow of the river while the main fill is under construction, consist of five tunnels, twenty feet in diameter and averaging 4050 feet in length. After the dam is completed these tunnels will be converted so that they can be used to deliver water to the power generating station and to regulate the flows in the river below the dam.

The spillway location utilizes a natural depression created by Coteau Creek which flows in the South Saskatchewan River just below the main fill. The overall length of the spillway will be 17,000 feet of which 8,000 will be approach channel, 3,800 feet concrete control structure and 6,000 feet exit channel. The spillway will have a discharge capacity of 265,000 cubic feet of water per second to take care of any future flood conditions that might be expected to occur.

An auxiliary earth dam will be built at the divide between the Qu'Appelle Valley and Aiktow Creek which flows into the South Saskatchewan River, to control the flow of water from the main reservoir in the Qu'Appelle Valley. This will involve the building of a dam 90 feet high, 9,000 feet long and 700 feet wide at the base.

Construction: Ten contracts, totalling approximately 6¼ million dollars were awarded from October, 1958 to June 1, 1959. Tenders for the con-

• **Canadian Developments**

struction of Embankment, Stage 2 closed recently and the contract was awarded to Piggott Construction Co. Ltd., in the amount of $6,983,437.50. This brings the total of all contracts to approximately 13 million dollars.

The following summary outlines the construction activity on the South Saskatchewan River Project to June 1, 1959.

Access Roads: Two contracts totalling $341,149.60 were awarded to cover the construction of two access roads referred to as the east and north access roads. The east access road includes approximately twelve and one-half miles of road from Provincial Highway 19 to the damsite, while the north access road covers approximately sixteen miles of road extending from Provincial Highway 15 to the damsite and including access roads to the site.

Construction work on the East Access Road was started on September 5, 1958 and was completed early in 1959 by Evans Construction Co. Ltd., Saskatoon. Taylor Brothers of Regina started construction of the North Access Road in April. Progress has been satisfactory and approximately 50 per cent of the contract is complete.

Processing Aggregate: Work on this contract in the amount of $812,030.00 covering the production of six hundred and twenty-one thousand tons of concrete aggregate had not started. The contractor, McNamara Limited of Edmonton, Alberta, is actively employed setting up and testing the processing plant. Stripping of the stockpile area has been completed and it was expected that the processing plant would be in operation by June 15.

Headquarters Services and Buildings: Four contracts amounting to approximately $1,000,000 have been awarded for the purpose of providing Headquarters Services and Buildings. In general this work includes the construction of water, sewer and street systems, a well-point water supply system; and a pumping plant with appurtenant equipment to serve the construction headquarters. The contract for the headquarters buildings calls for the construction of forty housing units and five headquarters buildings.

Construction work was started on the headquarters buildings by Smith Bros. and Wilson of Regina, Saskatchewan, during December 1958. It is now estimated to be 95 per cent complete. Construction of services is being carried out by Beattie Ramsay Construction Company of Regina and work is progressing satisfactorily.

Construction Bridge: The construction of this bridge was divided into two separate contracts, namely the bridge substructure and bridge superstructure, totalling $1,285,225. The contract for the substructure was awarded to Foundation Company of Canada Limited, and called for the construction of four river piers and an abutment structure. The work has now been completed.

Bird Construction Company Limited were the successful bidders for the bridge superstructure which covers the supply and placing of structural steel, concrete deck and approach abutments. Completion date is scheduled for March 15, 1960.

Embankment, Stage I: This contract in the amount of $2,941,380. covers the construction of the embankment at the east abutment to elevation

1750 feet and involves approximately 8,000,000 cubic yards of material. Perini Limited of Toronto, Ontario, was the successful bidder and work commenced on March 25, 1959. The contract calls for this work to be complete by August 1, 1960. To date satisfactory progress has been made which consists mainly of stripping borrow and foundation areas, irrigating borrow pits and placing of compacted embankment.

Embankment, Stage II: This contract in the amount of $6,983,957.50 covers the construction of the embankment at the west abutment and involves approximately 18,000,000 cubic yards of material. Tenders closed on May 28, 1959 and the contract has been awarded to Piggott Construction Limited of Saskatoon.

Manitoba Flood Control Projects

Manitoba government engineers have started surveying alternate inlet locations for the 26-mile long Greater Winnipeg floodway designed to eliminate flood damage in the metropolitan area.

The $60-million project was one of several recommended by the Royal Commission on Flood Cost-Benefit. The other projects recommended, and now being studied by the government, include:

— A dam on the Assiniboine river near Russell

— A dam on the Assiniboine river near Holland

— A diversion from the Assiniboine river into lake Manitoba leaving the river near Portage la Prairie.

The Holland dam is being considered as a possible alternative to the Portage diversion.

Built in combination the flood control projects would almost completely eliminate flood damage in the Red and Assiniboine river valleys but not in the Upper Red River valley in the province. Further study will be given to control projects for this area.

Greater Winnipeg Floodway. The proposed floodway will have a capacity of 60,000 c.f.s. It will have a channel base width of 500 feet with slopes varying from six to one in clay areas to three to one in sand and gravel areas. The average depth will be about 35 feet but will vary along the course of the floodway from 24 to 67 feet. The plans call for acquisition of sufficient land to permit the excavated material to be deposited in a spoil bank on either side of the floodway.

A control structure will be required just below the floodway inlet on the Red River and an adjoining dike will have to be built running westward. Deposited material will provide a similar dike east of the river on the side of the floodway nearer the city. This dike and control structure will make it possible to raise the floodwater elevation upstream from the floodway and thus increase the flow through the floodway.

At the floodway's outlet a drop structure will be provided to discharge the flow in the floodway to the lower river elevation without causing erosion. The Seine river will be diverted permanently into the floodway.

In addition to these control structures there will have to be several highway and railroad bridge crossings as well as a crossing over the Greater Winnipeg aqueduct.

Russell Dam. This proposed dam costing $6.5-million, will be an earth-fill type with a concrete spillway, with top length of 3,600 feet and height of 78 feet above river bed.

The reservoir will extend upstream 56 miles from the dam and have a full surface area of 22,000 acres, a capacity of 450,000 acre-feet at spillway level and a full design level of 600,000 acre-feet. This reservoir would allow cutting off a flow of 15,000 c.f.s. for a 20-day period, in the Assiniboine. It would be of value in conserving water in dry years.

Portage Diversion. The proposed 18-mile long channel would leave the Assiniboine river, near Portage and run generally northward into Lake Manitoba. It would be a combination open channel and diked floodway, with a designed capacity of 25,000 c.f.s. The estimated cost would be $8,750,000.

An earth-fill and concrete control structure would be required in the Assiniboine river, and a concrete weir at the inlet of the floodway, and several drop structures along the course.

The weir would make it possible to keep water out of the channel when the natural flow of the river was less than 10,000 c.f.s. But when flood conditions existed in Greater Winnipeg a control dam across the river would make it possible to divert the complete flow on the Assiniboine into the diversion channel until the capacity of the diversion was reached. Beyond that point the gates on the dam would be lowered to maintain a constant capacity flow in the diversion channel.

Hand in hand with the proposed diversion is a project designed to regulate the level on Lake Manitoba. The Fairford river enlargement plan will allow water to be drained into Lake Manitoba from the Assiniboine river without causing unduly high water on the lake. It would consist of enlarging the existing Fairford river outlet channel to allow greater flows out of the lake during heavy inflow periods. A control structure in this channel would help maintain a satisfactory minimum elevation during periods of low inflow. The estimated cost of this enlargement will be about $1½-million.

Holland Dam. The Holland dam is still under investigation as a possible alternative to the Portage diversion. Its contemplated capacity could be two or three times that of the Russell dam but the practical design capacity is dependent on the results of the foundation investigation presently underway.

The Royal Commission also considered the possibility of widening, deepening and straightening the existing Red River as an alternative flood control measure. But to provide the same measure of protection as will be afforded by the floodway this kind of work would cost about $132-million — more than double the cost of the diversion.

The three major flood control projects on the Red and Assiniboine rivers are designed to provide protection to Greater Winnipeg for floods up to 169,000 c.f.s. below the confluence of the two rivers.

University News

University of Toronto

A new engineering course will be started at the University of Toronto in the autumn. It will be called Industrial Engineering, and is expected to meet a growing demand.

Those taking the course will study certain aspects of the various traditional branches of engineering and then concentrate on applied mathematics as their field of specialization.

A three year study of the course in Engineering and Business has brought a decision to discontinue it. Students desiring this training are advised to enrol in one of the conventional engineering courses and then to invest two additional years doing graduate work in business administration.

INTERNATIONAL NEWS

SWEDEN

A LARGE NEW SHIPYARD will be completed in 1962, at Gothenburg, the first clearing blasts having been made in March of this year.

Planned for "indoor" building of ships up to 100,000 tons on the assembly line principle, and featuring a series of advanced technical systems, the yard is being constructed by the Götaverken shipbuilders. Its annual capacity is planned at about 200,000 tons d.w., and it is estimated that building time for a 40,000 ton tanker will be reduced to 20 weeks. The aim is modernization of the shipyard's facilities, and the cost will be $30 million.

Starting from the completely mechanized plate yard at the far end of the plant, the material will proceed on roller lanes to plate and profiling workshops, welding shops and further on to the large assembly hall. Here the hull, stern first, is assembled in sections weighing up to 200 tons. Gradually, as new sections are added, the hull moves on rollers into one of the open-air building docks, each measuring 300 by 46 by 10.6 metres, where installation of machinery and other equipment is performed from dockside plants. The ship would be completed and ready for her trial run only two weeks after the prow has left the assembly hall —where the stern section for the next ship can immediately be put on the roller lane. The dock is filled with water and the finished ship is simply towed out.

The large width of the building docks, 46 m. will make it possible to build two 20,000 ton tankers simultaneously in the same dock. This ensures efficient use of the production facilities.

A NEW PULP QUALITY for papermaking, produced by a novel process pioneered by Stora Kopparberg, has been launched on the market. Known as "Stora 59", it is a bleached sulphite pulp made from pine wood. The principle of the process is that the wood is cooked in two stages, each with definitely different pH conditions. In the first stage the wood is impregnated and partly sulphonated with an almost neutral cooking liquid, while in the second stage the removal of the lignin is performed under acid conditions.

In order to obtain a highly soluble bisulphite, a sodium-base was chosen, as it makes for less hydrolytic destruction of the valuable hemicellulose components in comparison with the conventional sulphite process. Furthermore, it makes possible the grading of the quality characteristics of the pulp over a much wider range.

Month to Month

News of the Institute and the Profession

Confederation Ballot

Ballots were mailed to 10,835 corporate members whose fees were recorded as "paid" at close of business, June 4, 1959.

The ballot was closed at 5:00 P.M. July 3rd and the results recorded by the scrutineers are as follows:—

"Yes" votes	3,628
"No" votes	192
Spoiled ballots	2
Unidentified	15
Total	3,837

Miss May McLaren Retires

E.I.C. Staff Pays Tribute

The E.I.C. staff held a farewell dinner for May McLaren on June 30. This was the day on which Miss McLaren's many years of service with the Institute were completed, with her retirement.

The whole staff took part in this tribute to a co-worker whom they have loved and admired. But, remarkably, for all the implications of sadness the dinner turned out to be a gay affair, a good party for a really grand person.

For there was no prospect of inactivity for Miss McLaren. She was starting out almost immediately on a month-long trip to San Francisco, Los Angeles, and the Grand Canyon. And there were suggestions of absorbing activities, also, after her trip.

General Secretary Garnet Page started the very informal after dinner talk with a toast to the guest of honour. Dr. Austin Wright was present, and being the person best able to tell the story of May McLaren's long and important service to the E.I.C. he did this effectively. People close to Institute work have known or guessed how deeply she was involved. But, largely unknown to the membership, her unfailing assistance to the general secretary made many projects possible. Dr. Wright mentioned some of the projects on which her help had been invaluable—over and above a large share of responsibility for the routine of the Institute operations, and for the welfare of the staff.

The staff presented two gifts to May: a clock-radio which they hoped would entertain and please, and a purse of money which they asked her to use according to her own inclination.

Miss McLaren (left) received her gift from friend and co-worker Miss Maudie Abraham, of headquarters.

Miss McLaren gave a talk that was really entertaining. She spoke about the four general secretaries she had worked with, the many friends she had made among the members and their wives, and the travelling she had enjoyed.

ASME-E.I.C., Calgary

Calgary, Alberta was chosen as the location of the June meeting of the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers. It was held on June 1-3, 1959, with headquarters in the Palliser Hotel.

The Calgary Branch of the Engineering Institute sponsored this meeting on one of the very few occasions when the ASME Committee of some 80 members has held its regional meeting in Canada.

The purpose of these meetings is to hear and consider suggested changes in the ASME Code, and to discuss and interpret specific cases. The agenda included meetings of sub-committees on non-destructive testing, on welding, on power boilers, on heating boilers and on unfired pressure vessels, as well as the main committee on boiler and pressure vessels. Among the decisions reached was one permitting wider use of castings in nuclear reactors covered by the Boiler and Pressure Vessel Code. If confirmed by letter ballot, the ruling will be issued in the near future.

It was an extremely successful session. The Canadians offered their guests many social events, including a western barbeque and entertainment, sponsored by the province, the Calgary Branch of the Institute of Power Engineers and the ASME.

Planning and arrangements for the program were carried out by P. S. Grant, M.E.I.C., and Neil Carr, M.E.I.C., chairman and vice-chairman of the committee on arrangements, and Gerald Coughlin, president of the Calgary Branch of the Institute of Power Engineers.

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 June 7, 1959.

Member: S. G. Beckett, Toronto; H. R. Brand, Jamaica; P. W. Breithaupt, Toronto; G. R. Cook, Niagara Falls; K. J. Lee, Toronto; A. F. Provenzano, Vernon; R. G. Regimbal, Copper Cliff; K. G. Richardson, Toronto; H. K. Sandlos, Sarnia; T. Smith, Sarnia; J. W. Wilde, Toronto.

Junior: N. F. Budgen, Winnipeg; T. J. Flint, Sarnia; W. H. Harley, Toronto; P. G. R. M. Waddell, Ottawa.

Affiliate: C. G. Lenihan, Vancouver.

Junior to Member: D. E. Morrison, Toronto; R. J. Nesbitt, Lauzon; R. W. Rogers, New Westminster.

STUDENTS ADMITTED

University of Toronto: P. J. O'Higgins, A. H. Tilt, J. A. Underwood.

University of Alberta: D. J. Winkel.

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. D. Meeres; **Junior to Member:** A. G. Swanson; **Student to Junior:** W. N. Hasegawa.

NOVA SCOTIA

Members: A. F. Goodwin, J. J. Hernon, G. R. Oulton, J. F. Vajda; **Junior to Member:** G. E. J. Blaiklock, D. C. Menchions, J. R. Soy.

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations.

QUEBEC

Abstracted from the *Bulletin* of the CPEQ, May, 1959.

The Annual General Meeting

The 1959 annual general meeting of the Corporation was very well attended: about 150 members were at the morning session and attendance rose close to 300 in the afternoon.

Committee Reports

As announced previously, a morning session was held this year for the exclusive purpose of discussing the reports submitted by the various Corporation Committees. These reports were received but held for discusion at a forthcoming meeting of Council.

In connection with the report of the Remuneration Committee, some explanations were provided on the background of the Report on Salaries. It was reported that the figures quoted in the Report were obtained through a survey in which twenty-eight Quebec firms and some sixty-five Ontario firms participated. The figures shown in the Report were representative of salaries actually paid by these firms.

The Report of the Committee on the Advancement of the Employee Engineer drew much interest. It was reported that the Committee had produced a form of employment agreement for possible use as a guide to individual engineers and had recommended to Council that this form be made available to the membership. It was pointed out, however, that the Committee did not find it appropriate at this time to recommend that the use of written agreements be encouraged by the Corporation. Council agreed with these views and a form of agreement prepared by the Committee is to be made available as soon as it is reviewed by the legal adviser.

The Committee on Consulting Practice recommended in its report that Consulting Engineers be treated as a distinct group in the Code of Ethics and also that the title "Consulting Engineer" be defined either in the Act, By-Laws or Code of Ethics. A revision of the Tariff of Minimum Fees was also recommended by the Committee.

Regular Business

In the afternoon session, Council's Report for 1958 as distributed to the membership in printed form was discussed and approved. Likewise, the Treasurer's report appearing as an appendix to Council's Report was approved.

Some members commented on the fact that eligibility to our Group Life Insurance Plan is restricted to members below age 60. It was felt that there should be a higher age limit so that older members may join the plan. It was pointed out, however, that premiums at all ages would have to be raised substantially if the age limit were extended.

ALBERTA

Annual Meeting—Committee Reports

Abstracted from *The Alberta Professional Engineer*, June 1959.

Giving the Chair to C. A. Stollery (the Vice-President) Dr. G. W. Govier, in his capacity of Chairman of the Acts and By-Laws Committee, outlined the work that his committee had done, and indicated in detail the changes in the wording of the Act that had been approved by Council. These changes allowed for the separate designations of Engineers, Geologists and Geophysicists (Council had rejected the suggestion that Scientists be registered). An "eminent persons" clause, accepted by Council by a majority of one, was the subject of some discussion, and the clause was rejected by a vote of 62 to 42. The amended Act will go before Legislature next session.

Reports from Committees on Counselling and Education, Discipline, Enforcement, and Consulting Practice, were unanimously approved.

The Public Relations Committee report was presented by Mr. J. Longworth, who described to members the aims of his Committee: to promote, both inside and outside the Association, pride in and recognition of the Association's work. The Committee, to this end, had formulated a ceremony for the presentation of membership certificates (the first ceremony was held in Edmonton on January 23, 1959), had instituted a new and improved seal, and had distributed copies of the new information booklet "The Engineer and His Profession." Liaison with University students continued through the annual luncheon held this year on March 21 and, with the approval of Council, arrangements were to be made to present meritorious high school students with slide rules. Association news and opinions had been transmitted to reading members by the five published copies of The Alberta Professional Engineer. Mr. Longworth concluded by expressing his appreciation of the Association's Public Relations Counsel, McConnell-Eastman Ltd.

In his Committee's report on Engineer's salaries, the Chairman Mr. T. D. Stanley indicated that the small number of replies to the questionnaires (barely over 50%) seemed to imply that members were perhaps not very interested in the survey. Mr. Stanley endorsed the new Salaries booklet and felt sure that the membership would approve of it. He also presented curves indicating the results of the earnings' survey.

The report from the Special Committee on Mechanical Engineering at the University of Alberta was happily introduced by Dr. Govier, who told the meeting that the establishment of a degree course in Mechanical Engineering had just been announced by the University President, Dr. W. H. Johns. The meeting applauded this news and the appointment of Dr. George Ford as Department head.

MANITOBA

Record Attendance at Annual Dance

Four hundred and seventy-eight people, the largest turn-out ever, attended the Association's Annual Banquet and Dance at the Royal Alexandra Hotel. From the opening cocktail party through the banquet and on to the dancing, the large crowd enjoyed themselves thoroughly.

All branches of the profession were well represented with large groups coming from the Manitoba Civil Service, the Manitoba Hydro-Electric Board, the construction industry and the consulting fields. President Les Wardrop hosted members of his firm at the gathering.

Councillor, R. E. Chant, P.Eng.

The election of Professor R. E. Chant to the Association Council at the annual meeting adds another chapter to the very colorful career of one of the well-known members.

First Lady Engineer

At the last session, the Provincial council unanimously concurred to accept Mrs. E. Kuiper (nee Minka Van der Schaaf) into the Association. This is the first time in the history of the provincial organization that a lady has been admitted as a member. This welcome precedent could not have been set by a more charming lady.

Mr. Edward Kuiper, her husband, is a well known member of our Association. They have five children who were born in three different countries.

Personals

Dr. R. L. Hearn, M.E.I.C. (Toronto, '13) has been appointed deputy chairman of the board of British Newfoundland Corporation Limited in Montreal.

Robert J. Askin, M.E.I.C. (Queen's '23) of Abitibi Power & Paper Company, Limited has been appointed executive vice-president (development, engineering and services) for the company in Toronto.

M. Neil Hay, M.E.I.C. (Queen's '23) works manager of the Aluminum Company of Canada Limited, Kingston, Ontario, has retired after many years of service with the company.

E. R. Smallhorn, M.E.I.C., (McGill, '23), consulting engineer, has been elected mayor of Senneville, Que.

M. S. Fotheringham, M.E.I.C., (Toronto '31), was awarded the International Nickel Company of Canada, Limited, platinum medal during the annual dinner of the Canadian Institute of Mining and Metallurgy in April. Mr. Fotheringham is president and general manager of Steep Rock Iron Mines, Limited, and vice-president and director of Premium Iron Ores Limited.

D. O. D. Ramsdale, M.E.I.C., (McGill '33), manager of transformer department, English Electric Co. of Canada Ltd., was elected chairman of the Niagara Peninsula Branch of the Institute, at the Branch annual meeting.

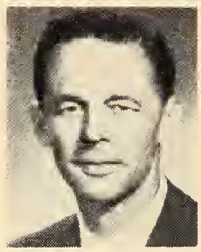

Robert J. Askin, M.E.I.C.


D. O. D. Ramsdale, M.E.I.C.

A. H. Pask, M.E.I.C. (Manitoba, '35) has been appointed chief engineer with the Greater Winnipeg Gas Company.

F. W. Cranston, M.E.I.C., (Queen's '36) has been appointed a vice-president of Babcock-Wilcox and Goldie-McCulloch Limited, and will retain responsibilities related to his present position as general sales manager. An incorrect reference to this appointment was made in the June issue of the *Journal*, for which the editors sincerely apologize.

W. O. Horwood, M.E.I.C. (McGill, '37) of International Equipment Company Limited is the general sales manager for the company's Montreal office.


W. O. Horwood, M.E.I.C.


William S. Allen, M.E.I.C.

Dr. G. G. Meyerhof, M.E.I.C. (London, '38) has accepted an invitation by the National Research Council of Canada to become a member of the Council's Associate Committee on Soil and Snow Mechanics. He is head of the department of civil engineering, Nova Scotia Technical College, Halifax, N.S.

F. A. Davis, M.E.I.C. (Queen's, '40) of Foundation of Canada Engineering Corporation Limited is division engineer with the petroleum and petroleum chemical division in Toronto.

William S. Allen, M.E.I.C (Queen's '43) has been elected to the board of directors of Racey, MacCallum and Associates Limited, Montreal. He is executive engineer, Toronto division.

E. F. J. Clark, M.E.I.C. (Toronto, '47) has recently been made manager of the Toronto sales office of Canada Cement Company, Limited.

J. Brown, M.E.I.C. of Dominion Structural Steel Limited, Toronto, has been appointed assistant to the president.

H. J. T. Patterson, M.E.I.C. (McGill, '48) has been appointed Montreal district sales manager for the Dominion Structural Steel Limited.

C. Peter Jones, M.E.I.C., (British Columbia '48), partner in the firm of Read, Jones, Christoffersen, Vancouver, is the chairman of the Vancouver Branch of the Institute, having been elected at the recent annual meeting.

A. G. Watt, M.E.I.C., has been appointed manager of the structural division of the Saint John Dry Dock Co. Ltd., East Saint John, N.B.


H. J. T. Patterson, M.E.I.C.


C. Peter Jones, M.E.I.C.

Rear Admiral (E) Brian Roff Spencer, M.E.I.C., chief of Naval Technical Services, (R.N. Engr. College, England, '49) has been appointed to the board of directors of Canadian Arsenals Limited.

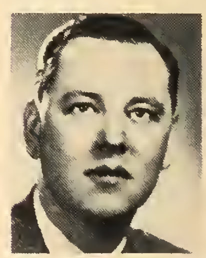
R. Kenneth Robertson, M.E.I.C. (McGill, '49) is the general manager of the Quebec division of Cooksville-Laprairie Brick Limited.

W. E. Dowbiggin, M.E.I.C. (McGill, '50) has recently been appointed manager, gas products, of Linde Company in Alberta.

D. McNicol Lowe, M.E.I.C. has been appointed resident engineer for Foundation of Canada Engineering Corporation Ltd. on the St. John's harbour improvement project at St. John's, Newfoundland.

Kaljo Tammik, M.E.I.C. (Sweden, '57), formerly of London, Ontario, is now assistant to general manager with Walsh Canadian Construction Company Limited in Montreal.

Gordon F. Coates, JR.E.I.C. (Alberta, '48) has been appointed manager of the highway division, Mannix Company Limited, Calgary.

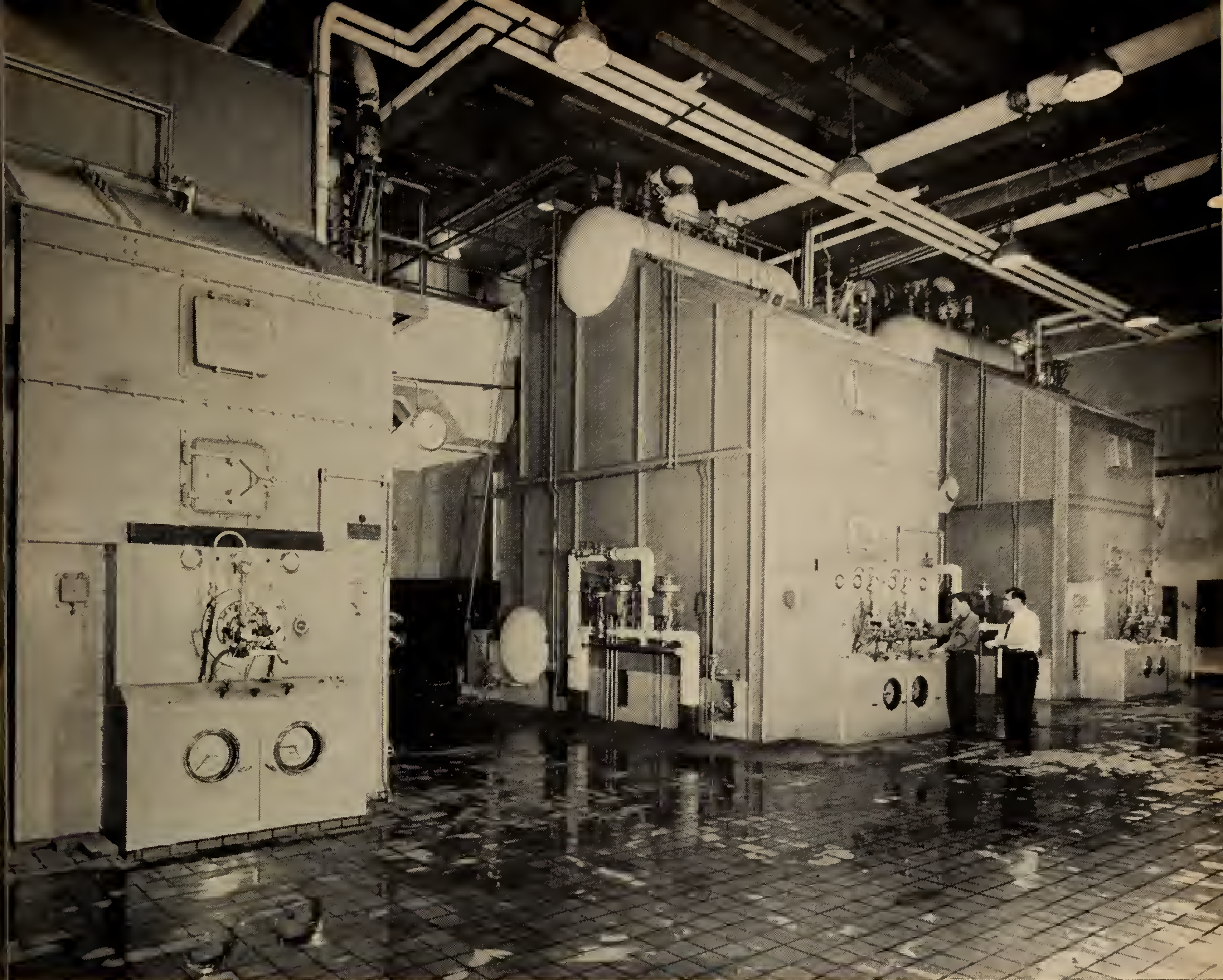

J. Brown, M.E.I.C.


R. Kenneth Robertson, M.E.I.C.

S/L N. B. Flavin, JR.E.I.C. (Alberta, '50, Mass. '59) has completed his masters degree at Massachusetts Institute of Technology. He is now at Air Force Headquarters in the Directorate of Systems Evaluation, Ottawa.


W. E. Dowbiggin, M.E.I.C.


E. F. J. Clark, M.E.I.C.

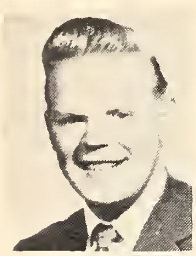


Marcel Lapierre, JR.E.I.C. (Ecole Polytechnique, '50) has been made assistant manager of the industrial sales department for Hydro-Quebec.

John R. Challis, JR.E.I.C. (Toronto '51) formerly of Montreal has joined the staff of Kilborn Engineering (1954) Limited, Toronto as resident engineer on projects in the St. Catharines, Ont. area for the St. Lawrence Seaway Authority.

D. A. Young, JR.E.I.C. (Manitoba, '52) has been appointed secretary of the Foundation of Canada Engineering Corporation Limited in Montreal.

Richard M. Girling, JR.E.I.C. (Saskatchewan '57) is resident engineer with Haddin, Davis & Brown Limited, Edmonton, Alberta.



Gregory Dewhurst, Jr.E.I.C.

H. A. L. McGuire, S.E.I.C.

Gregory Dewhurst, JR.E.I.C. (Saskatchewan '57) of Honeywell Controls Limited, Calgary has transferred to the industrial division sales and service for the Calgary and Edmonton areas.

F. E. Roy, S.E.I.C. (Manitoba, '58), formerly at Avro Aircraft Limited has accepted a position with the Department of National Defence, inspection services, in Ottawa.

H. A. L. McGuire, S.E.I.C. has been awarded a scholarship in engineering from the Foundation Company of Canada Limited and will continue his studies at the Nova Scotia Technical College.

OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here.

Hugh Robertson, M.E.I.C., died on February 24, 1959.

Born on June 6, 1886 in Helensburgh, Scotland, he graduated from Technical College, Glasgow, Scotland.

During the early part of his career he assisted in the design of various bridges and steel buildings. From 1908 to 1912 he was resident engineer on the construction of roads, sewers and various buildings in Scotland.

In 1912 he became draftsman and transitman with the C.P.R. at Montreal and Toronto and in 1913 to 1915 he was a transitman of the C.P.R. in Toronto. Later he worked in the Canadian Inspection Company, with the Ontario Hydro Electric Power Commission and with the Ontario Department of Highways.

In 1950 he was bridge engineer with the Department of Highways in Ontario.

Col. C. Arthur Scott, M.E.I.C., British Columbia commissioner of the Canadian Red Cross died on April 4, 1959. He had been commissioner for fifteen years.

During World War I, he served from 1915 to 1919 as an officer with the Queen's Own Rifles.

Before coming to British Columbia in 1944 from Toronto where he was born, Colonel Scott was national field directoı of the Red Cross. From 1940 to 1942 as overseas commissioner with headquarters in London.

He designed and carried out the construction of the Canadian Red Cross Hospital at Taplow. The first civilian Red Cross blood donor service was set up under his supervision in B.C. in 1947.

Earlier, Colonel Scott was a roadway engineer for the city of Toronto.

Claud Norris Rands, M.E.I.C., president of Rands and Associates, died on June 2, 1959, at Regina, Sask.

Mr. Rands was born in Portsmouth, England. He graduated from London University. During World War II he served as a lieutenant in the RNVR. After coming to Canada in 1951 he headed Rands and Associates, a geological consulting firm in Calgary and Edmonton.

Mr. Rands was an active member of various organizations and a Fullbright Fellow to the U.S.A. to carry out postgraduate research in sedimentology.

Gordon Reed, M.E.I.C., president of the Quebec branch of the Canadian Handicrafts Guild, died on March 27, 1959 in St. Sauveur, Quebec. He was a practising architect in Montreal.

Born on September 17, 1895 in Ottawa, Ontario, he attended Lower Canada College and McGill University. He graduated in 1922 with a B.Sc. degree in civil engineering.

During both World Wars he served with the Royal Canadian Army, retiring with the rank of Major.

Mr. Reed was vice-president of the Historical Sights and Monuments Commission of Quebec, and a member of The Quebec Association of Architects and the Royal Architects Institute of Canada.

Correction

Egon Alzner, M.E.I.C., whose death was reported in June, 1959 issue, was a graduate, 1928, from Technische Hochschule in Munich where he received the title of Diplom Ingenieur in mechanical engineering. He later studied for a year at the Technische Hochschule in Charlottenburg, Berlin. On this information about graduation the *Journal* item was inaccurate.

E.I.C. Annual General Meeting, 1960

Royal Alexandra Hotel, Winnipeg, Man., May 25-26-27.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

The two-page insert of Canada Wire and Cable Company Limited, pages 157-158 of the May issue of the *Journal* has been voted the "best" in that issue by a jury of fifty readers. Judging was based on ACCURACY - INFORMATION - ATTRACTION. This is the second time this Company's advertising has been voted "the best in the issue" since the award of certificates was commenced in January of this year.

The insert is printed in four colours on the front and in black and red on the reverse side. The copy on the front page covers a special cold chamber in the advertisers' development laboratory in which samples of wire and cable were tested for flexibility at -100°F. On the other side there is a description of the "Vertozone" continuous vertical vulcanizing process designed to improve ozone resistance of high voltage cables.

The advertisement was prepared and placed by Walsh Advertising Company Ltd., Toronto.

CANADA WIRE AND CABLE WINS SECOND AWARD

The Canada Wire and Cable Co. Ltd., two page, four colour, insert was voted the best in the May issue from the viewpoints of ACCURACY-INFORMATION-ATTRACTION.

Front **Back**

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

Editor: Garnet T. Page, M.E.I.C.
Associate Editor: J. Hance Legere, M.E.I.C.
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September 1959
vol. 42 no. 9

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

MEMBERSHIP

ABC CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index
The Canadian Business and Technical Index.

(19,700 copies of this issue printed)

MEET THE AUTHORS

R. L. Clark, Commissioner of Works, The Municipality of Metropolitan Toronto *(The Humber Sewage Treatment Plant)*.

Mr. Clark graduated in engineering from the University of Toronto in 1937 with a B.A.Sc. He worked as mechanical superintendent of the Consumers' Gas Company of Toronto, held the rank of flight-lieutenant with the R.C.A.F. as a navigator during the first part of the war and later was a construction and maintenance engineer on the Northwest Staging Route in the Yukon and Northwest Territories. In 1946 he joined the engineering ranks of the City of Toronto and was appointed Cimmissioner of Works of the Metropolitan Corporation in July 1956.

Y. DeGuise, M.E.I.C., assistant chief engineer, regional operation division, Quebec Hydro *(The Beauharnois No. 3 Development)*.

Mr. DeGuise graduated from Ecole Polytechnique in Montreal in 1937 and completed the Canadian General Electric Company two-year test course in 1939. He worked for Provincial Hydraulic Service of Quebec until 1945 when he joined Quebec Hydro. He was resident engineer at Beauharnois plant from 1947 to 1951 and superintending engineer of generating stations 1951-1953. He has held his present position since 1954.

From 1943-1955 he also lectured in water power engineering at Ecole Polytechnique.

Mr. DeGuise is a member of the Corporation of Professional Engineers of Quebec, American Institute of Electrical Engineers and other electrical societies.

C. Forest, M.E.I.C., assistant chief engineer, power development division, Hydro-Quebec *(The Beauharnois No. 3 Construction and Development)*.

Mr. Forest obtained his B.A. in 1936 from Montreal University and graduated from Ecole Polytechnique in 1941. From 1941 to 1943 he was with the Civil Aviation Division of Department of Transport. From May 1943 he was field engineer on the Beauharnois canal until 1946, with Beauharnois Light Heat & Power and Hydro-Quebec. In 1946 and 1947 he was field engineer on Beauharnois No. 1. From 1948 until 1952, resident engineer on Beauharnois No. 2. In 1952, superintending engineer of construction in the Montreal head office of the power development division of Hydro-Quebec. In 1953, Mr. Forest was transferred to Bersimis Lac Casse project as assistant project manager. In 1954, Mr. Forest came back to Head office as special assistant to the chief engineer, in 1956 became general superintending engineer of construction and in 1958 assistant chief engineer.

A. J. Bachmeier, head of the gas dynamics section, and **R. A. Tyler**, senior research officer, both of the division of mechanical engineering, National Research Council *(A Gas Turbine Power Plant for Locomotives)*.

Mr. Bachmeier is a graduate of the University of Saskatchewan and has been with N.R.C. since 1946.

Mr. Tyler is a graduate of the University of London and joined the N.R.C. Council in 1947.

J. Featonby, designer, **E. S. Moore**, designer and **D. C. MacPhail**, director, all of the division of mechanical engineering, National Research Council *(A Gas Turbine Power Plant for Locomotives)*.

Mr. Featonby worked for Armstrong Siddeley Motors Ltd., Coventry, England, before joining the N.R.C. in 1948.

Mr. Moore worked for D. Napier & Son, Alton, London, England before he joined N.R.C. in 1949.

Dr. MacPhail is a graduate of the University of British Columbia and came to N.R.C. in 1948 from the Royal Aircraft Establishment, Farnborough, England.

R. J. Kennedy, M.E.I.C., department of civil engineering, Queen's University *(Littoral Drift in Lake Ontario Harbours)*.

Professor Kennedy graduated from Queen's University in 1941 with honours and the medal in civil engineering.

During the years 1941 to 1946 he served with the R.C.E. and was awarded the military cross at Arnhem in Holland.

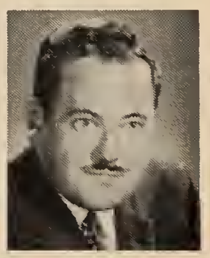
From 1946 to 1948 he was teaching at Queen's University then spent a year at the State University of Iowa on the J. Waldo Smith Hydraulic Fellowship of A.S.C.E. Returned to Queen's where he has been on the staff to date. Professor Kennedy has been supervisor of the Pulp and Paper Research Institute of Canada for project RC-12 since 1952. He was awarded the R. W. Angus medal of the Engineering Institute of Canada in 1958.

A. Brebner, department of civil engineering, Queen's University *(Littoral Drift in Lake Ontario Harbours)*.

Dr. Brebner graduated from the University of Aberdeen, Scotland in 1947 and received his doctoral degree there in 1952.

During the Second World War he served as pilot in the R.A.F. Dr. Brebner was on the staff of the Kent Rivers Catchment Board and taught at Aberdeen University. Since 1957 he has been a member of staff at Queen's University.

Dr. Brebner is an associate member of the Institution of Civil Engineers, a member of the International Association for Hydraulic Research and has published numerous papers on structural and hydraulic topics.



N. R. Grover, M.E.I.C., supervising engineer plant department, engineering headquarters, Canadian Broadcasting Corporation *(C.B.C. Studios 7 and 42 Video and Audio Facilities)*.

Mr. Grover was born in Saskatchewan and obtained his early education there. During the World War II he flew with the R.A.F. Ferry Command. In 1945 he joined the Canadian Broadcasting Corporation.

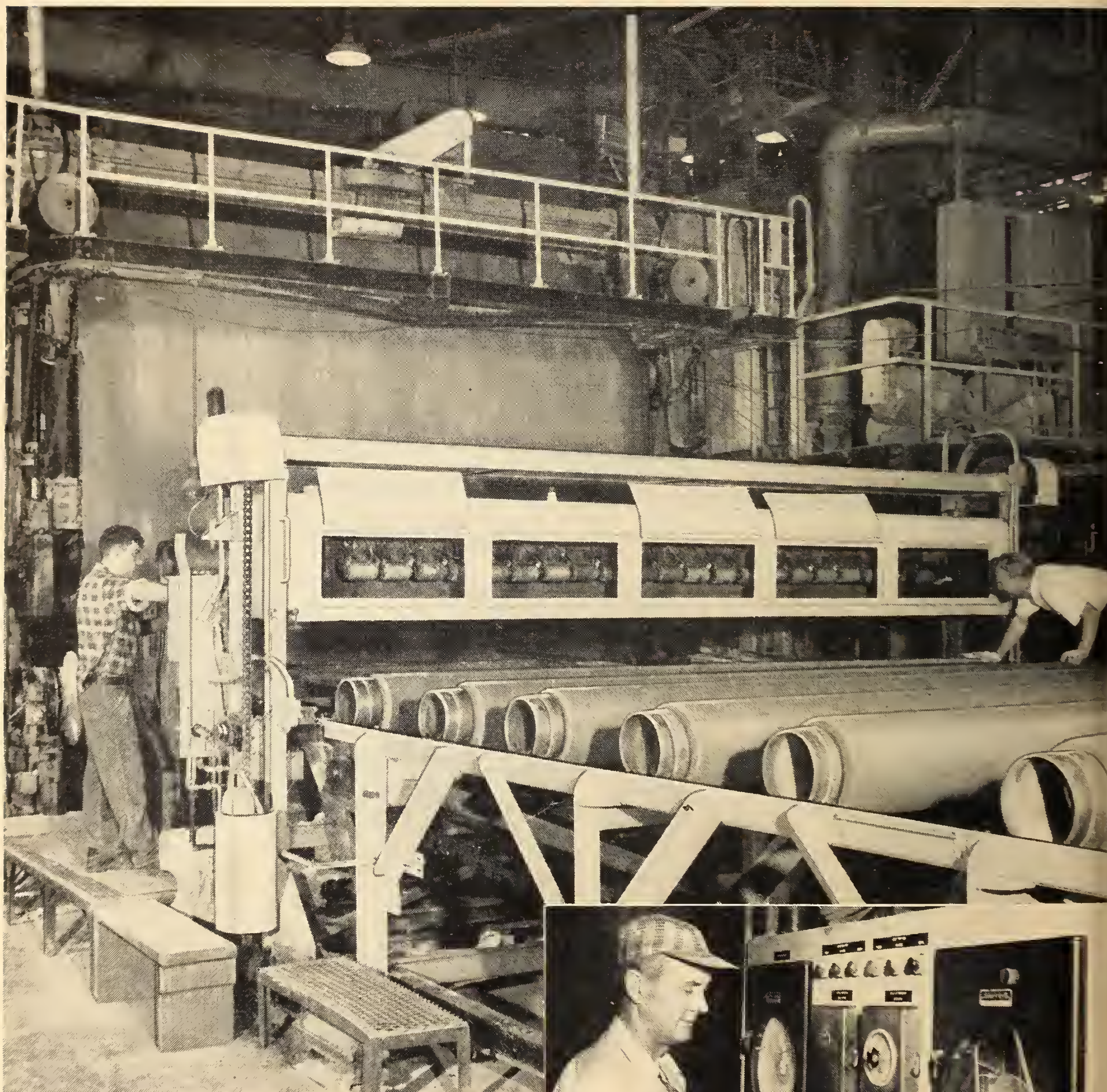
He received his B.Sc. from Sir George Williams College in Montreal.

Mr. Grover is a member of the Corporation of Professional Engineers of Quebec.

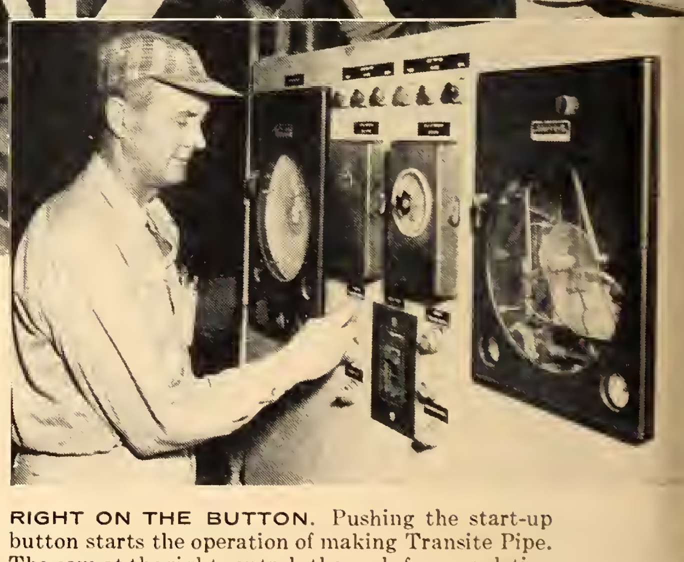
At time of going to press no information was available on **Mr. S. G. Anderson.**

Our cover picture shows the Humber Sewage Treatment Plant, Metropolitan Toronto, near its completion. In the foreground are shown final settling tanks with the return sludge pumping station on the right. Behind the aeration tanks is the blower building and head house. To the left are the two primary sludge pumping stations.

INCREASED



ABOUT TO TAKE THE CURE. Formed Transite Pipe rolls down the runway on its way to the steam curing chambers. Transite Pipes are used for water and sewage systems, underground conduits, venting etc.



RIGHT ON THE BUTTON. Pushing the start-up button starts the operation of making Transite Pipe. The cam at the right controls the cycle for completing the particular size of pipe in production. Pre-cut cams are available for various sizes of pipe.

THE HUMBER SEWAGE TREATMENT PLANT

R. L. Clark, *Commissioner of Works*
The Municipality of Metropolitan Toronto

BY AN ACT of the Provincial Legislature in 1953, The Municipality of Metropolitan Toronto was established, to provide certain essential services for thirteen adjacent municipalities. This action culminated nearly three years of discussions, hearings, and intensive studies of existing conditions by the Ontario Municipal Board, and eight months of research and consideration by a Government Committee.

The Metropolitan Area comprises approximately 153,000 acres, with a population of 1,429,000 according to the most recent tabulation. It is 24 miles across in an east-west direction with a north-south depth of close to 12 miles.

Services for which the new Corporation became responsible were: water supply, sewage disposal, housing, education, arterial highways, metropolitan parks, certain welfare services, transportation, finance, assessment, administration of justice, and over-all planning.

Immediately prior to incorporation, many of the member municipalities, shown in Table I, were inadequately served with sanitary drainage and sewage treatment facilities.

The City of Toronto System for the most part was the combined type with sewage being treated at the North Toronto and the Main Sewage Treatment Plants. The former plant, which also accommodated the Town of Leaside and the Village of Forest Hill in addition to small areas from the Township of North York, was treating an amount of sewage well above its designed capacity, but was still producing a reasonably good effluent. The latter plant was treating practically 90% of the sanitary flow originating within the City's boundaries and was providing primary treatment with approximately 50% of the suspended solids being removed.

The Pharmacy Sewage Treatment Plant was accepting the sanitary flow from the western portion of the Township of Scarborough, providing approximately 50% removal of the suspended solids. This particular unit, although recently enlarged, was rapidly becoming overloaded. A large number of septic tanks for individual properties were in use.

The Township of East York was operating two plants, namely, Todmorden and Danforth Park, each of which was severely overloaded, providing only 55% removal of the suspended solids.

The Township of North York had six small sewage treatment plants, each of them providing 87 to 94% removal of solids; nevertheless, accommodating only 50% of the population and a very small area in relation to the Township's acreage. They were rapidly becoming overloaded due to development in their tributary areas. A seventh plant (Don Mills) was under construction by a development company with the approval of the Township. Small sections of the Township of North York were served by connections to the sanitary systems of the Townships of East York and York, the City of Toronto, and the Town of Weston, which were providing sewage treatment accommodation through agreements. An extensive portion of the population in the Township of North York was served by septic tanks which were proving to be unsatisfactory in many cases, due to soil conditions.

The Weston Sewage Treatment Plant had been enlarged to accommodate the Town of Weston and portions of the Townships of Etobicoke and North York. Although it was providing moderately good treatment at the time, it was obvious that the rapid development in the areas of North York and Etobicoke would soon create serious overloading.

The Rockcliffe Plant served a concentrated population in the Township of York but, due to its limited size, was providing only 40% removal of the suspended solids.

Swansea Village Treatment Plant was accepting more sewage than it could accommodate, with the result that only 48% of the solids were being recovered.

Table I

Area Municipality	*Acreage*	*Population* 1951	1958
Township of East York	3,747	64,616	68,319
Township of Etobicoke	27,312	53,779	121,720
Village of Forest Hill	739	15,305	19,936
Town of Leaside	1,126	16,233	16,409
Village of Long Branch	750	8,727	11,026
Town of Mimico	500	11,342	14,401
Town of New Toronto	659	11,194	11,912
Township of North York	44,588	85,897	200,185
Township of Scarborough	45,012	56,292	168,281
Village of Swansea	682	8,072	8,972
City of Toronto	22,287	675,754	658,420
Town of Weston	622	8,677	9,485
Township of York	5,050	101,582	119,966

(See Fig. I)

Sanitary sewage from the southern portion of Etobicoke Township was handled at the recently constructed Etobicoke Sewage Treatment Plant, situated on Mimico Creek near the lake front. This area was only partially developed, and the plant was providing efficient treatment. However, development in the tributary area was proceeding at a very rapid rate, and there was every indication that extended facilities would have to be provided. Small areas of the Township drained to the Mimico and Long Branch Systems under agreement.

New Toronto and Mimico were accommodated by the Union Sewage Treatment Plant situated in the Town of Mimico. Due to the inlet flow containing extensive amounts of industrial waste, this plant had been severely taxed for a number of years.

The Long Branch Treatment Plant served the Village of Long Branch, a small section of the Township of Etobicoke, and limited areas in Toronto Township, and was accepting sewage beyond its capacity with unsatisfactory results.

Evidence indicated that each Area Municipality had endeavoured to assist its neighbour in acquiring sanitary drainage accommodation for its residents, but the existing sewage plants and trunk sewers-deemed escapacity required if all citizens were to be provided with accommodation. In addition, many of the sanitary trunk sewers in the Area Municipalities were of insufficient size to permit drainage from one Municipality into its neighbour system to any extent. There had been no adoption of a co-ordinated master plan for sewage plants and trunk sewers deemed essential for the development of a satisfactory Metropolitan sewerage system.

The numerous overloaded sewage treatment plants which discharged their respective effluents to the various rivers located throughout the Metropolitan area, or directly through outfall sewers to the lake, were causing rather severe pollution in Lake Ontario, from which the water supply for most of our residents was derived.

The foregoing will serve to illustrate the situation with regard to sanitary sewerage facilities which existed when the Metropolitan Council first convened in early 1954 for the purpose of providing the thirteen Area Municipalities with essential services.

Capital Works Program adopted to provide adequate sanitary drainage for the Metropolitan Area

A capital works program designed to provide the Metropolitan Area with

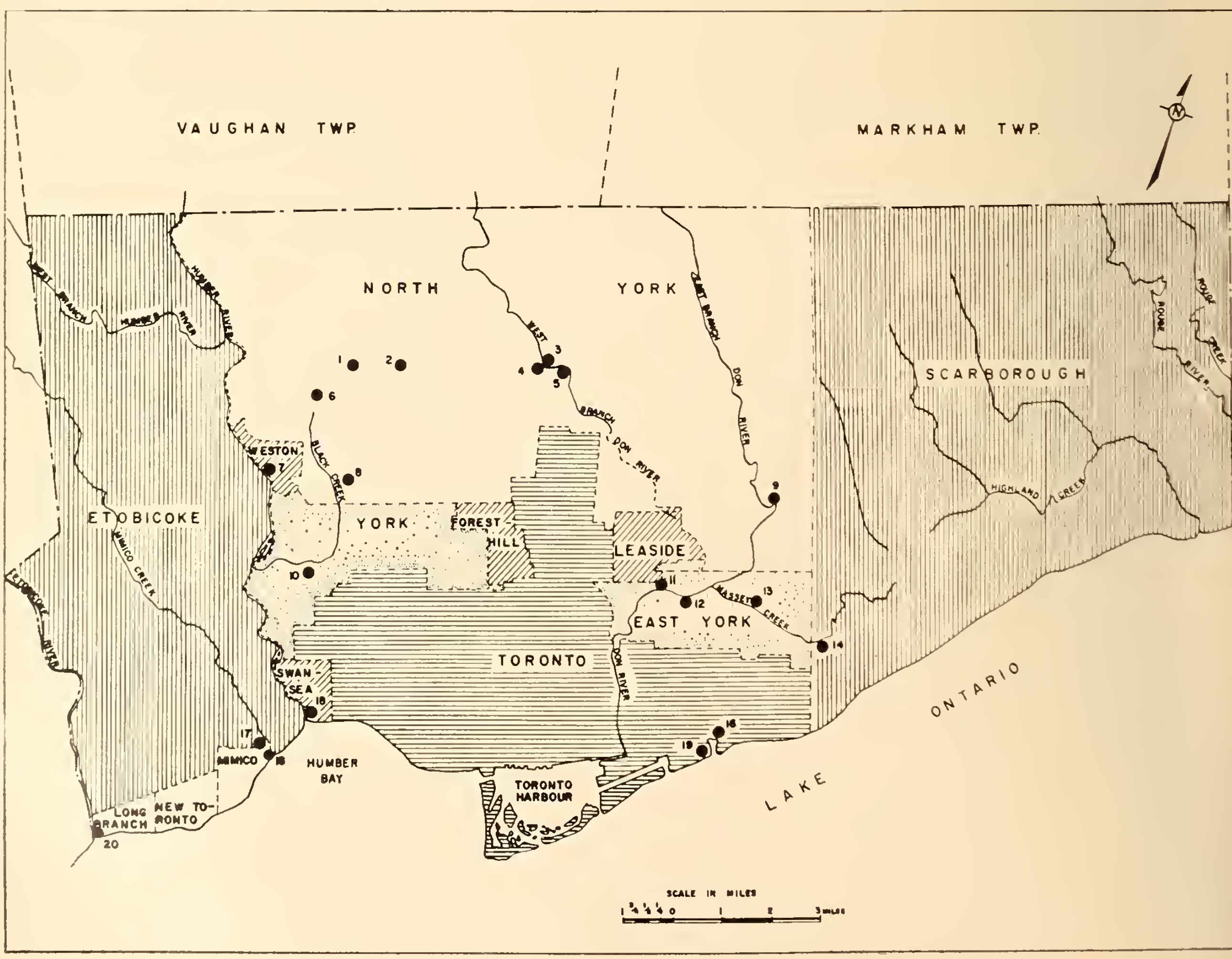
Fig 1. Plan showing Metropolitan limits, Area Municipalities' limits, and location of existing sewage treatment plants.

SEWAGE PLANTS

1 *Baker Downs;* 2 *R.C.A.F.;* 3 *Gwendolen;* 4 *Glendale;* 5 *Armour Heights;* 6 *Jane-Wilson;* 7 *Weston;* 8 *Delray;* 9 *Don Mills;* 10 *Rockcliff;* 11 *North Toronto;* 12 *Todmorden;* 13 *Danforth;* 14 *Pharmacy;* 15 *Swansea;* 16 *Main P.S.;* 17 *Union;* 18 *Etobicoke;* 19 *Main;* 20 *Long Branch.*

LEGEND

Metropolitan Toronto Boundary —— . ——
Sewage Treatment Plant - - - - - -
Municipality Boundary ●



adequate sewage treatment plants and sanitary trunk sewers to convey the sewage to them, was adopted by Metropolitan Council in its first year of operation — it being planned to conform with the recommendations made in a report, dated January 30, 1954, prepared by Messrs. Gore and Storrie, Consultants, outlining sewage disposal requirements necessary to adequately service all thirteen member municipalities.

In general, the scheme embraces major treatment plants at the mouths of the larger rivers in the Metropolitan area, with sanitary trunk sewer systems extending northerly from each plant for collection purposes. Extensions and improvements to certain existing plants are also included. The estimated cost of the over-all program, including plants and sewers, is $90 million.

The major plants under construction—planned in all cases to remove 90 to 95% of the suspended solids and biochemical oxygen demand — and their initial capacities, are set out in Table II.

Table II

Plant	*Daily Capacity being provided*
Highland Creek (new plant)	4,000,000 gals. per day*
Main Plant (Ashbridge's Bay) (Enlargement and Improvement)	120,000,000 gals. per day
Humber (new plant)	50,000,000 gals. per day*
Long Branch (new plant)	To be decided
Glendale (Extension)	3,000,000 gals. per day
Weston (Extension)	6,700,000 gals. per day

*Provision made for extensive enlargements when required.
(See Figs. 1 and 2 for location of the plants and associated sewers.)

The pollution control program being carried out by Metropolitan Toronto is comparable to any instituted to date on this continent. One of the more important facets of this work is the establishment of a new treatment plant at the mouth of the Humber River and its associated trunk sewer development, to which this paper is devoted.

In developing the Capital Sewerage Works Program for the Metropolitan Corporation in 1954, the consulting engineers found that conditions in the Don and Humber Rivers were totally unsatisfactory. The bacterial counts in the lower portions of the rivers were exceedingly high, and there were excessive quantities of suspended solids and oxygen demand. Obviously, the pollutional load had been increasing rapidly with the post-war expansion. To limit the bacterial count in these streams to the maximum recommended by the Ontario Department of Health, i.e. an mpn* count of 2400 per 100 millilitres, elimination of all normal disposal of sewage effluents was imperative.

Accordingly, this situation dictated that any plant constructed at the mouth of the Humber River must serve a complete trunk sewer system extending northerly therefrom to the northern Metropolitan boundary, with all existing inadequate plants within the watershed being eliminated.

The consultants, to estimate the degree of treatment required at the new plants, carried out extensive research on the various water intakes along the shore of the lake and on the lake currents. Results of the study decreed that any plant built within the Metropolitan boundaries must be based on supplying complete treatment.

*most probable number

Engineering Appointment

With some of the general principles established respecting the Humber Drainage System and the type of plant to be provided, Metropolitan Council appointed James F. MacLaren Associates in April 1954 "To supply all engineering services incidental to the development of the project to accommodate and treat the sanitary drainage from the entire Humber River watershed within the geographic limits of the Metropolitan Area as designated by the Corporation." In carrying out its commission, this firm decided to consult with the firm of Alvord, Burdick and Howson of Chicago, Illinois.

The initial authorization defined the general limits of the tributary area, but detailed analyses of the existing sewerage systems and their planned development within the various municipalities concerned were to be conducted to ascertain the actual limits to be served eventually.

Functional sketches with approximate estimates of cost were to be made for review and endorsement at the outset of the engineering assignment.

Population in Tributary Area

The watershed of the Humber River and its tributaries within the limits of Metropolitan Toronto embraces an area of 34,200 acres representing six municipalities, namely the western part of the Township of North York, practically all of the Township of York, the Town of Weston, the Village of Swansea, a major portion of the Township of Etobicoke, and a large percentage of Wards 6 and 7 in the western section of the City of Toronto. Early studies of the areas tributary to the proposed treatment plant indicated that they were somewhat more extensive than the watershed proper, due mainly to the existing sewerage systems in the various included municipalities, which at certain points had been extended beyond the watershed's limits.

In the case of the Township of Etobicoke, it became obvious that the existing trunk sewer discharging sewage for treatment to the Etobicoke Plant would have to be diverted to discharge its flow to the new Humber Plant, and that at such time it would be desirable to similarly divert the sanitary waste from the Towns of New Toronto and Mimico. It also appeared realistic to provide for sewage flows from a very limited area of the watershed beyond the northern limits of the Metropolitan Corporation, to ensure that no future sewage treatment plants would be established on the Humber River or its tributaries within, say, one half-mile of the Metropolitan limits.

From these studies, it became evident that the ultimate area contributing sewage to the Humber Plant would be close to 50,000 acres, or about one-third of the land area within Metro. The ultimate resident population to be accommodated by the Plant would approximate 800,000. Fig. 2 indicates the tributary area and the main interceptor sewers that were planned in the initial report to convey sewage to the proposed plant.

Review of existing land use in the tributary area and the zoning plans for the undeveloped districts indicated that nearly 45% of the district would be utilized for residential development, 2% for commercial pursuits, 20% for industrial purposes, 17% for roads and 16% for parks, schools and utility rights-of-way. Ultimate density of the residential area was calculated to be 39 persons per acre, as against a future density in the whole area of 16.3 persons per acre.

Analysis of actual development in the tributary area indicated at that time (1954) that it had a population of 304,000, or 38% of the estimated ultimate, with the greatest concentration being in the two wards of the City, previously mentioned, and in the Township of York, which accounted for two-thirds of the existing tributary population.

Densities in the Townships of Etobicoke and North York were less than three persons per acre, indicating that practically all future growth could be expected within their limits.

Data assembled on expected growth in the tributary area indicated a conservative population increase of 15,000 a year; accordingly, it was assumed its final population would be attained by the year 1990. In the four years which have elapsed since this study was made, the population increase within the area confirms the initial assumption.

Design Flow and Strength of Sewage

Two methods were employed to determine the anticipated tributary flow, initially and ultimately, from the area to be served. On one basis, actual unit flows of sewage on an acreage basis were computed from water consumption figures according to residential, commercial and industrial uses. Such figures were then applied to existing and ultimate land use areas to determine the estimated flow.

As a confirmation, the sewage flow each hour of the 24 hour day over a one week period was gauged at existing sewage plants and in main trunk sewers. The flows determined from such gaugings were then compared with the results obtained by applying the aforementioned unit area flows to the development applicable in the area tributary to the gauging point. It was found that satisfactory co-relation existed between the two methods and, accordingly, the existing and ultimate flow conditions were established, provision being made in the latter figure for some future increase due to an expected increase in the per capita consumption of water.

Gaugings in 1954 indicated that an average flow of some 28 to 29 million gallons a day (or 96 gallons per day per capita) was originating from the planned tributary area. The b.o.d. of the sewage was calculated from the sampling data to be 530 parts per million, the suspended solids 310 parts per million, and the grease content 190 parts per million. These figures represented exceptionally strong sewage, which could be generally traced to the large flow from the tributary district of the City of Toronto. The flow from this district was found to be 12.5 m.g.d., of which 9 m.g.d. was derived from packing houses situated in the vicinity of Keele Street and St. Clair Avenue. The strength of the sewage for the whole area would have been approximately one-half that indicated if packing houses were discharging wastes of the strength found in domestic sewage.

In view of the existing and estimated population of the area, its calculated rate of growth and its present sewage flow and strength, it was determined that a plant initially capable of treating a daily average flow of 50 million gallons of raw sewage, from a population of 475,000 persons, be constructed, capable of treating sewage with an average b.o.d. of 260 p.p.m., a suspended solids content of 210 p.p.m., and a grease content of 75 p.p.m. Since the initial design population would be in existence by 1973, the layout was made in such fashion as to permit for enlargement to 100 million gallons capacity, deriving from the ultimate pre-determined population of 800,000.

Site Selection and Development

The location proposed for the Humber Sewage Treatment Plant was originally recommended in the Capital Works Program prepared by Gore and Storrie in 1954. It incorporated the existing Humber Valley Golf Course to the west of the Humber River and north of Queen Street Extension, in the district known as "Humber Bay."

Accepting the consultants' recommendation, Metropolitan Toronto purchased the Humber Valley Golf Course in 1955 comprising 89 acres, of which approximately 26 were located in the flats known as "The Marsh" alongside the Humber River. This site made it possible for sewage originating throughout the watershed to be discharged to the proposed plant by gravity sewers. Furthermore, it permitted discharge of any treated effluent from the site to the lake at a maximum distance from existing waterworks intakes.

A housing development bordered the acquired property on the southwest extremity, and Stonegate Road — a residential street with modern and expensive homes — constituted the northerly boundary. A large apartment development, recently established, was situated a short distance to the north.

Because the Golf Course site had originally been utilized as a source of clay for a brickyard operation, the contours of the ground varied radically in steep slopes from elevation 250 to 310. Two main ridges extended from west to east across the property, with slopes towards the river on the easterly boundary.

An extensive marsh adjacent to the river was a source of unsightly reeds, due to the apparent high organic nature of its contents. Normally, the marsh area is moderately dry when the river level is within its normal limits of elevation 244 to 248 but, on occasion, its level has been raised to approximately 260, as was the case during Hurricane Hazel. Instability of sub-soil in this region denied the use of 26 acres of the property for actual plant installations.

Initially, a provisional lay-out using a north-south axis, immediately west of the marsh area, was considered. However, it was abandoned in favour of an east-west lay-out paralleling the Queensway. The final proposal required expropriation of a further 26 acres located to the south-west of the original property, on which scattered residential development existed.

In planning the new lay-out, maximum separation of the plant from the developed areas was to be secured by construction of a high ridge (elevation 310) on the west and north sides of the site, which could be built with the large quantity of earth involved in the plant excavation work. It was further proposed that the main grade elevation throughout the site be established at 270, and that the greater portion of the hydraulic structures be set down at 260.

Establishment of the base grade for the site and the topography of the property indicated a total excavation of 1,000,000 cubic yards, of which approximately 300,000 cubic yards would be derived from the excavation for structures after the completion of rough grading. This quantity was deposited in the ridge and on the marsh. However, due to the instability of the latter, it could only be safely filled to an elevation of 260 and then only for half its width.

In order that the Corporation might proceed with construction in the location finally selected, an amendment to the official plan for the area was requested, since the Golf Course property was officially designated as *Green Belt*. This amendment understandably was declined, in view of the objections raised by neighbouring home owners to the construction of the plant. Accordingly, the Metropolitan Council appealed to the Ontario

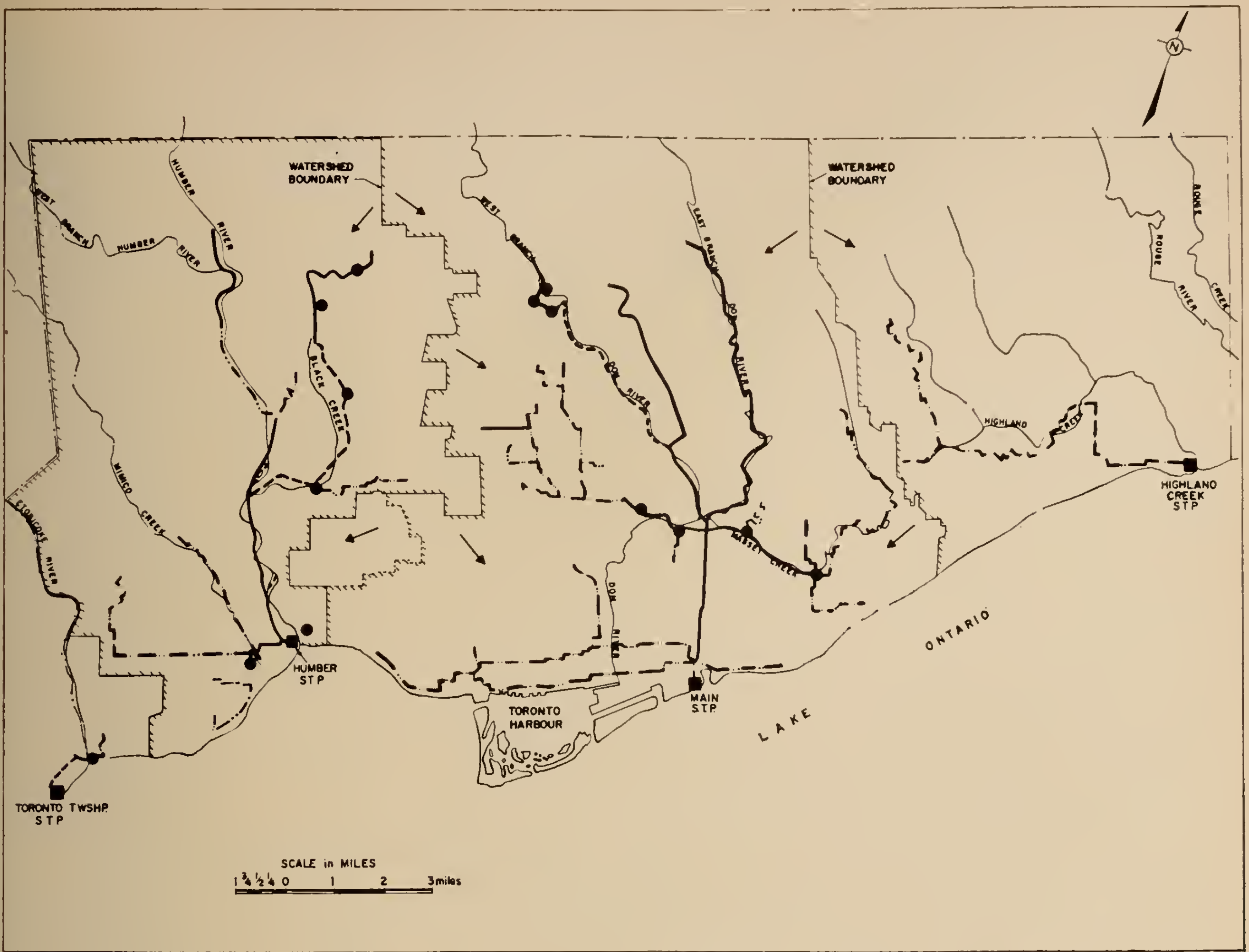


Fig 2. Plan showing ultimate development of sewage works programme.

LEGEND

Sewers installed before Metro or by others but now owned by Metro	— .. — .. —
Sewers completed or under construction by Metro	———
Sewers to be constructed by Metro	— — — —
Metropolitan Toronto Boundary	— . —
Drainage Area Boundary	———
Existing Plants to be abandoned	●
Permanent Plants	■

Municipal Board for the desired amendment. Subsequently, the Board held a full hearing on the subject, carefully investigating each objection presented by the ratepayers and other affected Bodies.

Finally on June 22, 1955, the Ontario Municipal Board approved of the zoning amendment, thus permitting construction to proceed. In granting its approval, however, the Board placed certain limitations on the Metropolitan Corporation in the use of the site for the stated purpose and on the structures to be erected thereon. Basically, some of these limitations had already been suggested by the Metropolitan Corporation in its functional plans. The significant sections of the directive required that the Corporation utilize all the area of the property outside of the plant fixtures for development of landscaped park lands; and that a screen be made of tree planting around the plant periphery; and, insofar as practicable, the digestion tanks be located below ground level with sludge and other wastes being processed and handled in enclosed buildings.

The objections raised to the establishment of the plant on the Humber Golf Club site required a full review of all other practicable locations for the plant's establishment. At the time of the Board hearing, five alternative proposals were investigated in detail. However, it was concluded that of all the sites studied, the one at the mouth of the Humber River was the most feasible. This fact was based mainly on economy, for it was found that to construct the ultimate plant in any other area would entail at least two million dollars more expenditure.

Tributary Trunk Sewers

Before outlining plant facilities in detail, it may be helpful to review briefly the trunk system required to convey sewage to the plant. Referring to Fig. 2; sewage will be received from two main sources and one secondary source. The Humber River Sanitary Trunk Sewer — the largest of these — will extend northerly from the sewage plant along the west bank of the Humber River through the Township of Etobicoke and the Kingsway District some 19,000 ft. to the junction point of the Humber River and Black Creek.

This major sewer is at present under construction, the lower 3,000 ft. being under soft ground tunnel conditions requiring up to 15 pounds of air to control ground water, with the major section located in rock at an average depth of 70 ft. below surface level.

The tunnel varies from 9-ft. diameter at the lower end to 8-ft. 6-in. in the rock portion, and it has an over-all capacity of 400 cu. ft. per sec. An emergency overflow to the Humber River to prevent surcharging during times of extreme flood in the river will be built at the lower end.

Because complaints could be anticipated through construction of the sewer in the residential areas, no shafts were permitted in the rock tunnel contract; all entrances to the work being driven in adit from the bank of the river immediately above water level. Alternative tender prices were sought for carrying out construction with and without the use of explosives. The non-explosive alternative envisaged use of rock boring equipment which had been satisfactorily employed on the Oahe Dam in Missouri. When bids were received it was evident that the non-explosive alternative could be employed at substantially the same cost as would be required for normal blasting methods and, accordingly, this alternative was selected. Progress on the tunnel is now being made, using a Robbins rock boring machine for excavation at a net rate of 25 ft. per 24 hours, although some difficulty was experienced at the start in getting the mechanical equipment tuned up. Specifications call for a 12-in. unreinforced concrete wall with pressure grout to a minimum pressure of 80 p.s.i. being placed after the wall concrete has set.

At the junction of Black Creek and the Humber River two sanitary sewers extend further north; one, the Black Creek Sanitary, extends northerly along the line of Black Creek, intercepting flow from the York Township combined sewerage system up to a maximum of 2½ times the average dry weather flow and accepting packing house wastes, which are to be diverted from the City of Toronto sewerage system. (When this sewer is available, Rockcliffe Plant will be converted to provide storm water treatment to flows received from the York Township sewerage system during excessive runoff periods.) From Rockcliffe Plant, the sewer continues northerly in 60-in. to 48-in. diameter size to the Metropolitan limits, accepting flows along its length from various municipal systems including the diversion of flows now tributary to existing sewage treatment plants scheduled to be abandoned. This work is currently being expedited with completion planned for 1960.

The other sewer, known as the Etobicoke Sanitary Trunk, continues northerly from the previously mentioned junction point along the Humber River, accepting flows from municipal systems as it progresses up river to the Weston Sewage Treatment Plant (to be abandoned), at which point all tributary flows will be connected to the trunk. This sewer is at present being extended in sections up to the northern boundary of the Metropolitan Area. Coincidently with this work, the Townships of Etobicoke and North York are improving their sewerage systems to make the necessary connections thereto on a permanent basis.

The second main feature of the tributary system to the Humber Sewage Treatment Plant is known as the Queensway Sanitary Sewer, which extends westerly from the plant along the Queensway to Park Lawn Road and across Mimico Creek. It will intercept flows now tributary to the Etobicoke Sewage Plant and the Mimico-New Toronto Union Sewage Treatment Plant. Diversion of flows from these plants will permit the abandonment of the latter plant and utilization of the more recent Etobicoke Plant for a dewatering facility to serve the new Humber installation. The Queensway Trunk Sewer, established at a diameter of 66-inches, will be constructed in mixed face conditions through its lower section, altering to complete rock tunnel as it progresses upstream, with the sections to the west of Mimico Creek to be constructed in open cut. Work on this project is well under way.

A secondary, but third measure, in the diversion of flows for treatment at the Humber Plant calls for replacement of the obsolete Swansea Plant with a new pumping station capable of pumping maximum anticipated flows through a steel forcemain across the Humber River on the Queensway bridge to the new plant site.

The foregoing trunk sewers and intercepting devices represent the responsibility of the Municipality of Metropolitan Toronto. Sewers necessary to connect to this system are the responsibility of the individual municipalities concerned and, as previously noted, are being carried out in conjunction with the Metropolitan Corporation's program, so that a fully unified development can be in satisfactory operation by mid-1960.

Soil Investigations

Preliminary soil investigations on the Humber Golf Course indicated the overburden to be grey silty clay with 90 to 95% by weight passing a No. 200 mesh. Unconfined compressive tests indicated the bearing value was as low as 1000 lb. per sq. ft. and as high as 3,500 p.s.f., with the weaker soils occurring at depth. It appeared that such material would be extremely difficult to compact when wet, its moisture content varying from 12.6 to 25.6%, while its liquid limits varied from 21.0 to 38.3 and its plastic limits from 16.1 to 20.1%. No groundwater problems at levels above the lake surface were revealed.

The soil, being extremely variable in bearing capacity, was not attractive for support of the proposed structures, which despite low imposed unit loading would, nevertheless, be extensive. Fortunately, the underside of most proposed structures would extend below elevation 250, and laminated shale was encountered throughout the site at a depth varying from elevation 256 in the west to 238 in the east. It therefore appeared feasible to establish all major foundations on the shale rock which, although shattered especially in its top strata, was found to be adequate for the maximum imposed loading of 3,500 lb. per sq. ft.

Conditions encountered in the marsh area were entirely contrary to those prevailing on the remainder of the site and are of some interest. Fifty to eighty ft. of organic silt with little measurable resistance rested on a shale bottom. Obviously this material was inadequate to support the heavy structures, and it was questionable if it would support placement of fill. Since the marsh area was desirable as an excavation disposal zone to reduce off-site handling, extensive laboratory investigations were carried out to ascertain how far consolidation would occur if fill was placed in the area. It was feared that stability might be overcome sufficiently to cause the silt to shift and destroy the hydraulic capacity of the river. However, on review of all information, it was determined the area could be filled to a depth of 15 ft. over half its width with a settlement of 3 ft. resulting, being 90% complete after a period of 6 months. Careful filling during construction permitted this procedure to be followed, and no noticeable settlement occurred after the first six months.

Plant Features

As previously mentioned, complete treatment of the sewage tributary to the Humber Plant was mandatory for proper protection of waterworks intakes located within two to three miles of the plant outfall, and to protect adjacent beaches. This demanded 90% reduction of b.o.d. and suspended solids in the raw sewage and, during the summer months at least, post chlorination. Primary settling followed by secondary treatment based on the activated sludge process appeared to be the logical process to adopt in order to protect the receiving body to the extent required.

Operating results and experiences obtained from original plants at Milwaukee, Chicago and Indianapolis since 1925, together with experimentation and the development of the modern Chicago, New York, Cleveland, Philadelphia, Gary, and Columbus plants, were reviewed before making the final decision. Recent advances in design and improved operation methods have given added importance to the usefulness and flexibility of the activated sludge process. The options in sludge re-aeration, such as step aeration and biosorption, have further increased its attractiveness.

The final process procedure adopted for the plant comprises the following features:—

1. Trash Racks and Bar Screens;
2. Grit Chambers;
3. Pre-aeration Tanks;
4. Primary Settling Tanks with Grease Collecting Facilties;
5. Conventional Aeration Tanks designed to provide for Sludge Re-aeration and Step Aeration Facilities;
6. Final Settling Tanks;
7. Chlorination Facilities;
8. An Outfall Sewer to the Lake at depth;
9. Sludge Pumping Facilities to Digestion Tanks;
10. Sludge Digestion Facilities and Gas Storage Units;
11. Vacuum Filtration of Digested Sludge.

Centralized control will be achieved through incorporation of inlet structures, grit chambers, blower plant and administration offices in one building.

Having described in general form the pollutional control program, and especially the Humber project, the remainder of this paper will be devoted to detailed description of the various plant units.

Mechanical Screening and Inlet Facilities

The Head House contains the plant inlet facilities, including shut-off gates, screens and grit removal devices. Here the incoming sewage enters four separate but equal conduits, each controlled by a 7 ft. by 5 ft. sluice gate operated by an oil hydraulic system, in order that all flow can be shut off in the event of power failure or flood conditions in the Humber River.

Beyond these gates, the conduits become open channels, each approximately 11 ft. deep and 5 to 8 ft. wide, in which the screening devices will operate.

Each channel is equipped with a trash rack and coarse screen, similar to the New York practice. The use of trash racks with 15° slopes, each unit having mechanical cleaners discharging to tipping buckets, was considered expedient to protect the screens from damage due to floating debris. Bar spacing was set at 3 in.

Similarly, the bar screens were established with a 1 in. clear spacing, which was deemed sufficient to stop the passage of injurious material to pumps and other equipment further on in the plant process. The screens were set at an angle of 30° off the vertical to control the fall-back of material caught on the rakes. Raking mechanisms operate electrically, being actuated by either a time clock or a high water float control. All screenings enter tipping buckets.

With the foregoing spacings and maximum velocities through the screens limited to 2.5 ft. per sec., an average of 4 cu. ft. of screenings per million gal. should be recovered.

The possibility of grinding the screenings and returning them to the sewage flow was set aside in favour of daily disposal by a covered container capable of easy mounting on a truck.

Grit Removal

It is a well-founded concept that the heavy mineral matter carried in sewage, such as gravel, sand, cinders, ashes, coal and heavy organic matter, must be removed from the sewage flow as soon as possible to avert severe abrasive wear on internal plant pumps and equipment. It can also seriously affect the organic strength of the primary and biological sludges.

At the outset, 70% of the flow to this plant will derive from combined sewer areas where grit generally reaches the sewers in substantially greater quantities than from separate sewer areas. In addition, many miles of newly commissioned sewers, carrying sewage with an abnormally high grit content, will convey flow to the plant. For these reasons, facilities have been designed on the assumption that a grit content equivalent to normal combined sewage will be experienced in the initial years, although it is recognized that quantities should diminish as the new sewers become completely flushed and separation of some of the combined systems occurs.

Determination of the extent to which heavy material should be removed from the sewage is one of the main problems in grit chamber design. Also, present day practice dictates that grit be washed prior to disposal to reduce the putrescible content below 3% for odour control. Previous experience has been to collect 80% or more of the grit in sewage (i.e. that portion greater in size than 0.20 to 0.25 mm.) at maximum flow rates, thus effectively reducing abrasive problems in subsequent machinery while limiting organics in the grit to a reasonable level.

Three standard designs were considered for application to the Humber problem — (1) the straight-line rectangular tank with bucket type collector, (2) the aerated grit chamber, and (3) the square clarifier type. On review of the anticipated operating conditions which would prevail, two square clarifier type grit chambers were selected. These were located within the head house for odour control, and with classifiers to remove grit were substantially free of organic matter. Grit will be accumulated in tipping buckets and discharged daily to trucks for transportation to fill areas.

Pre-Aeration

Pre-treatment of sewage through the use of diffused air type pre-aeration tanks has become, in recent years, an increasingly attractive addition to many plants.

In the case of the "Humber", its inclusion was considered justified on the basis of (1) the control of odours, especially during warm weather and low flows; (2) the aid offered in the flotation of grease for subsequent removal in the primary settling tanks since grease is anticipated as a problem; (3) the protection of efficiency of the biological processes and the plant generally from shock industrial waste loads; and (4) a further safeguard against grit carry-over to mechanical equipment.

It was felt that retention time on pre-treatment should be set at not less than 60 minutes. In addition, it was deemed wise to utilize standard spiral flow type aeration tanks with diffused air equipment. To maintain a spiral flow velocity in the tank of approxmiately 2 ft. per sec., air diffusion at a minimum rate of 3 c.f.m. per lineal ft. of tank was necessary.

Primary Sedimentation

Primary sedimentation in modern activated sludge plants is standard practice as a multiple purpose unit designed mainly to reduce and regulate sewage strength and concentrate solids for disposal. The present day mechanically cleaned settling tank, however, is available in a number of shapes and sizes, each with its particular advantage.

The use of a circular settling tank (or square, which represents only a modification of the former) utilizing a horizontal rotating rake with ploughs moving sludge in the direction of rotation toward the base of the tank for removal, was given due consideration but was set aside in favour of a rectangular design. For this two alternative mechanisms were studied: (1) the bridge type with extended bottom scrapers and surface skimmer, and (2) the straight line drag type chain collector. The latter was selected finally, designed with surface return for scum and grease collection at dip troughs, primary sludge being concentrated for removal at the inlet ends. The inlets have been baffled to confine short circuiting, and a weir length established sufficient to confine overflow rates to prevent formation of strong outlet currents and subsequent inefficiency. To accommodate sufficient trough length within the tanks, all troughs were arranged parallel to the flow at the effluent end.

Cross-collectors at the influent end of each tank will concentrate sludge from each pair of tanks to a central point where it enters the suction side of piping connected to pumps located in the two primary sludge pumping stations. Each station is equipped with two 50 g.p.m. positive displacement sludge pumps, with vari-drive for discharging sludge at a continuous rate to the digestion tanks and one 300 g.p.m. plunger pump for handling sludge on an intermittent basis and for tank drainage. The stations also have grease separation vats for storage of scum discharged from the surface of each pair of tanks. The contents of these vats will be heated from time to time to permit separation of the grease from liquid matter, and the former will be conveyed by Moyno pumps to containers or directly to trucks for disposal. Normally, sludge based on a concentration of 6% will be removed at the rate of 83,000 gallons per 24 hours, while it is anticipated that scum will be recovered at the rate of 20,000 lb. per day.

Aeration

The activated sludge process was first discovered by Ardern and Lockett at the University of Manchester in England, some forty-six years ago. Although the first North American plant of this type was built at San Marcos, Texas, in 1916, the large scale plants at Indianapolis, Milwaukee and Chicago were not put into operation until the end of the twenties, when the process became more widely accepted as a means for the complete treatment of sewage. Since that time several process variations have been developed, but the original unmodified installations have proved to be among the most efficient and economical operating today.

Basically, the activated sludge process is a contact operation in which the formation of biologically active flocs or slimes of living organisms is promoted under aerobic conditions, for the purpose of transferring to the floc putrescible (principally finely divided and dissolved) substances. These substances are partially stabilized by biological activity, some of the soluble and stable end products being returned to the plant flow, while excess biological flocs and their stored impurities are more or less continuously unloaded as waste activated sludge. Determination of the aeration tank volume and the weight of sludge that must be returned to it, along with the required amount of air to support the action if the desired purification is to be effected on the daily applied load, represents a major problem in design.

Correlation of all factors at the Humber indicated that the secondary treatment section should be designed on a conservative activated sludge basis, but with complete facilities incorporated for step aeration or some form of sludge re-aeration. It was, however, decided to make hydraulic provision for carrying flows 50% in excess of the anticipated design maximum. By so doing, if it is found that sludge re-aeration methods can produce adequate removals at considerable saving of aeration tank volume, the tank capacity will not have to be increased substantially in the future enlargement. In view of the extensive research currently being carried out on activated sludge, it was considered unwise to design a plant of this capacity without permitting the ultimate in flexibility.

Spiral flow diffused air procedures versus high rate mechanical aeration was given serious thought, and the former method was selected. In calculations, a sludge loading of 0.30 lb. of b.o.d. per lb. of mixed liquor suspended solids was used, with the latter to be maintained at a mean of 1700 p.p.m. Three pass tanks for the inlet of settled sewage at the beginning of each pass, with return sludge to be admitted at the beginning of the first pass, were selected as optimum for the Humber condition.

Air supply was based on providing a maximum of 1000 cu. ft. of air per pound of b.o.d. to be removed with an additional 33% in standby. Coarse bubble diffusers were favoured, due to their flexibility in handling air quantities over a 4 to 1 range while maintaining a practicable head loss condition. Their adaptability to higher than anticipated sewage strengths and to sludge re-aeration procedures also played a part in their selection. Spacing at 14-in. centres along the tank wall, with 16 units being carried on one 4-in. diameter header, was deemed adequate.

Effluent spray systems are affixed to all tanks to give a surface spray at the rate of one-third gal. per linear ft. of tank to control foaming that has become prevalent of late in many cities.

All air supply piping is galvanized steel located on wye walls between the tanks, while connections to the 4-in. diameter diffuser headers are made through valved down pipes located at 18 ft. centres.

An aeration control gallery located wholly below ground level was established to house all piping and controls. Settled sewage to each tank is metered through 36-in. and 20-in. venturi tubes with flow to each of the three outlets to a tank being controlled through 36 in. butterfly valves, the proportion to each outlet being gauged by the resulting solids concentration within the tank contents at each location, as measured by a 30 minute settling test. Air is metered through venturi inserts to the wall headers, while return sludge is discharged through rate controllers in equal proportions to each tank.

Final Sedimentation and Return Sludge

The prime development in the design of final settling tanks, in recent years, has been the recognition that density currents and their effects must be carefully assessed. The initial theory of sedimentation bears no relation in importance to the problem of density currents, insofar as the design of Sewage final settling tanks is concerned. The work of Anderson at Chicago and subsequent work of Gould at New York have brought these problems to the fore.

As a result of their investigations, tank depths must be selected most meticulously, despite the apparent adequacy of present surface loading rates; and there must be a limiting ratio between flow length or distance from the inlet to the upturn of the density current and the tank depth, in order to confine density current velocities. The use of offset weirs, as practised at the Humber, should further relieve the problem of density currents.

In addition, recent experience indicates that for proper final tank operation, quick removal of the return sludge must be achieved to maintain it as fresh as possible. Its retention time should not be more than 40 minutes within the tank, and it should be as concentrated as feasible at withdrawal, to confine the hydraulic requirements of sludge return.

Present limitations of surface loadings at 900 gal. per sq. ft. per day on final tanks, replacing older criteria of 2 to 2½ hours' detention, are therefore only established to obtain sufficiently quiescent conditions in the final tank flow to permit activated sludge to settle out as rapidly as practicable—generally within 30 to 40 minutes.

Final tank shapes and sludge collecting mechanisms are identical to those offered for the primary settling tanks, with the exception of an additional induced suction type of unit usually applicable to circular or square tanks. Preference for the latter was established in view of the ready means available for dealing with overflow rates and density current problems.

Although the rate for moving return sludge is actually determined by the solids concentration to be carried in the aeration tank liquor and the settling characteristics of the return sludge, it is often set with liberal limits as a percentage of the design rate of sewage flow.

Accordingly, the return sludge pumping station has five vertical type direct connected mixed flow electrically driven pumping units, each rated for 10.25 m.g.d. against a total head from all causes of 13 ft. Three of these units are normally used for the return of activated sludge to the aeration tanks, providing a ratio of 10 to 70% of the average design flow in return sludge capacity. The additional two units are employed for aeration or final tank drainage; for the wasting of excess activated sludge to the primary settling tanks; and as auxiliaries for return sludge service. A 3.6 m.g.d. and a 1.5 m.g.d. vertical type centrifugal pump are included in this station to pump screened effluent at a total head of 160 ft. for the aeration tank sprays, the flushing water system and the chlorine solution lines.

All sludge is returned to the inlet of the first pass of each aeration tank, equalized delivery to each tank being maintained through a rate controller system, pneumatically operated.

Chlorination

Disinfection of sewage plant effluents by chlorination is an important factor in the protection of municipal water supplies and bathing beaches. Even in the case where complete treatment is provided, the stabilized effluent always has substantial bacterial counts, some of which could be the pathogenic type. Post chlorination is essential to ensure maximum safety.

Use of chlorine in some of the individual operations within the plant process is also desirable. When required, control of odours and improvement in the removal of grease and the settling of solids may be achieved by addition of the chemical to the incoming sewage (prechlorination). Slime growths in the effluent flushing system can be minimized by small daily dosages of the disinfection, especially during warm weather. It also may be necessary on occasion to chlorinate the supernatant liquor from the digestion tanks, if the solids concentration reaches abnormal levels. Control of bulking on an emergency basis by the addition of chlorine to the return sludge is not uncommon.

Dosage rates vary for the different applications. Pre-chlorination, post-chlorination and return sludge control, representing the highest sewage flows, demand the larger quantities of chlorine with dosages varying from 1 to 12 p.p.m. Supernatant liquor can be considered minor flow requiring 25 to 300 p.p.m., with slime control calling for a moderate range of 2 to 10 p.p.m.

Four 8000 lb. per 24 hour, manually controlled, mechanical solution feed, vacuum type chlorinators are to be installed initially, one assigned to each of the three points of high chlorine demand with the fourth as an auxiliary. A 2000-lb. per 24 hours capacity machine is provided for supernatant liquor and effluent flushing application. All units draw chlorine from one ton containers set on weigh scales through electric heater type evaporators. (It was found impracticable to arrange tank car delivery of chlorine.) Each chlorinator is equipped with a flow recorder designed for a 20 to 1 range. Automatic proportioning of chlorine is not required, due to the continuous variation in organic content of the receiving flow.

Precautionary alarms to detect chlorine leaks and a special ventilating system form part of the safety equipment.

Air Blowers, Engines, Heating and Electrical Systems

Air requirements of the activated sludge process and the pre-aeration systems, previously described, dictated an average supply of 40,000 c.f.m. for the initial design flow and 60,000 c.f.m. for maximum flow, with 33% of maximum capacity being provided in standby.

Accordingly, four 20,000 c.f.m. units, operating at 8 p.s.i., will be installed initially, Nevertheless selection of the type of blower to be used, i.e. centrifugal or rotary, did require considerable research. Both are used widely on this continent for sewage treatment service, the latter not being available in sizes larger than 20,000 c.f.m. at the indicated pressure. The latter were selected finally to match the speed of the engine drivers, the selection of which will be discussed later. Special snubbers have been employed on the blower units to obtain a low noise level.

Filtration of the air supply to the degree normally required for some types of diffusers was not incorporated in the sewage tanks, in view of the selection of coarse bubble diffusers. Air cleaning, therefore, has been restricted to the use of single stage automatic self-cleaning type filters, employing an overlapping panel curtain rotating through an adhesive bath.

Methane gas generated in the sludge digestion tanks has served as a fuel for heating boilers in sewage treatment plants for about 30 years, and to some degree it has been utilized for development of motive power. But its use for power purposes can only be justified on the basis that production costs are lower than those quoted by the electrical utility. Thus, an economic analysis of the Humber project was made, comparing cost of power obtained through gas or dual fuel diesel engines against purchased power. Such analysis took account of all building and equipment costs as well as operating costs. It was found that the greatest economy could be achieved by driving the large air blowers with dual gas engines, using gas generated within the plant.

Rates and standards of service quoted by the local gas utility indicated that the use of natural gas (1000 Btu rating) as an auxiliary to the sludge gas (600 Btu) on a gas cycle engine would be cheaper than utilizing oil as standby to sludge gas on a dual fuel diesel engine. Accordingly, the blowers are to be driven by 1000 h.p. dual gas engines, operating at the blower rating speed of 333 r.p.m. The combined assembly will be mounted on a vibration isolating spring mounting system to control noise and vibration within reasonable limits.

Heat recovery devices on the engine cooling and exhaust systems are the primary heating element for the digestion tanks and plant buildings. Heat for the digestion tanks is provided from the engine cooling system through a hot water system operating between 140 and 160°F. The low pressure steam heating system for the building derives heat from exhaust gas recovery units, with standby steam boilers being provided to supply either the building system directly or the digestion system through steam to hot water converters.

The blower room, heating plant, workshop and control room are located in the main building along with the Head House and the administration section.

Ventilation of the main building is planned to ensure that no gases or odours reach dangerous or obnoxious proportions, all foul air being directed to the air blower suctions on a controlled basis and discharged through the diffuser system in the aeration tanks for odour control.

The plant electrical supply is obtained from an adjacent 27.6 kw.-feeder of the Etobicoke Hydro Electric Commission, and is transformed through the plant's main substation to 2300 volts. From this point, buried 2300 volt cables in duplicate are laid to transformer stations in the main building and return sludge pumping station, with feeders emanating from these points to eight 575 volt motor control centres (provided with lighting transformers and 120/208 volt low voltage systems), located about the plant. A floodlighting system is included to facilitate 24-hour operation, and all structures and galleries are equipped with emergency lighting systems using nickel cadmium batteries. Electrical equipment within the digestion control galleries is explosion proof.

Plant Hydraulics and Metering

Satisfactory flow through plant elements requires a difference in elevation between the level of the incoming sewage and Lake Ontario—the receiving waters for the effluent—to provide for various hydraulic losses. These head losses will vary with the rate of flow, and the efficient operation of the plant relies in large measure on the skill with which the losses have been assessed. In general, the hydraulic analysis of the Humber plant was based on the following considerations: assuming the highest controlled level of Lake Ontario (Seaway); providing for maximum flow with one of each type of unit out of service; allowing for free discharge over all weirs under such conditions; anticipating the later duplication of the plant; and ensuring average velocities of at least 2 ft. per sec. in all structures preceding the aeration tanks and at least 1 ft. per sec. in all succeeding structures. Kutter's formula was used to determine losses anticipated in the open channels, while Hazen and Williams' work was employed to compute losses in the conduits. Standardized coefficients related to velocity heads were required to establish losses due to turbulence, obstructions, openings, and changes in hydraulic area. Loss of energy caused by flow momenta at juncture points was not overlooked.

Final review of all hydraulic determinations and assumptions indicated that 13.5 ft. should be left between the maximum water level in the inlet sewer and top water level in the final settling tanks.

Adequate meter equipment plays an important role in any large sewage plant—indeed, its absence can make operation extremely inefficient. The cost normally is less than 2% of the project.

A location for the metering of the raw sewage has been selected between the grit removal and pre-aeration facilities where a concrete venturi tube, square in cross-section, is being cast in the connecting conduit, its throat reducing to a square of 42 in. from an inlet size of 84 in. square. The throat will be bronze lined and differential will be measured by a mercury well type electric transmitter. Settled sewage entering each of the five aeration tanks passes through 36 in. by 20 in. venturi tubes, which record flow with the aid of pneumatic transmitters of the nozzle-bellows, forced balanced type. Return sludge to each tank is metered through a 20-in. venturi tube having a 16 in. butterfly valve installed in the throat, the flow into No. 1 tank being manually set and pacing to an equal proportion the flow to all other tanks. Air to each aeration tank is metered through venturi insert nozzles, and both return sludge and air primary devices are provided with mercury operated pneumatic transmitters.

A venturi tube with a mercury well operated pneumatic transmitter accounts for the volume of waste-activated sludge handled, and all primary and digested sludge is measured by calibration of the reciprocating pumps and recording their period of operation on a time chart.

All meters are equipped with visual dials and transmitters, which relay data to totalizing and recording charts on the central control panel being established in the Main Building. Statistics on digestion tank temperature, gas pressure and engine operation are also accommodated on this panel.

Outlet Sewer

Outlet sewers for plant effluent should terminate well below the surface of the receiving waters, in order to disperse the fluid as rapidly and uniformly as possible. They must be located with careful regard to prevailing currents and proximity to water works intakes and bathing beaches. Multiple outlet risers along the line of the submerged outlet can be an important factor in ensuring that the effluent does not reach critical lake areas in concentrated form.

The outlet pipe for this installation will be placed in Humber Bay, immediately west of the mouth of the Humber River. This location has been adopted after careful study of both surface and depth currents, soil borings and sounding information — all made through the use of floating equipment. The shore section of the 10 ft. diameter outlet has already been constructed in concrete lined rock tunnel from the plant site, some 900 ft. southerly to the Lake shore. The 10-ft. diameter marine section will be under way shortly, extending 2200 ft. into the lake and terminating in fifteen 4-ft. diameter outlet ports at a depth of 23 ft. below normal lake level.

Soil investigations indicated that rock level dropped sharply from elevation 230 at the shore to 153 at a point 600 ft. out in the lake. At

1400 ft. from the shore it commenced to rise again, reaching an elevation of 200 at the 2200 ft. mark. For the intermediate area, the overburden was composed of silty sand varying from extremely weak to well compacted material on an irregular pattern. Because of this condition, it was decided to fabricate the pipe of welded steel in 60 ft. lengths with special flexible marine joints, and lay it in a specially constructed sand bedding with a minimum cover of 5 ft. Such construction will not increase the loading on the supporting soil, and the flexible pipe will provide for any slight settlement or variation in the bedding. Alternative tenders, however, may be requested, using reinforced concrete pipe with subaqueous joints delivered in 16 or 32 ft. lengths.

An emergency 6 ft. diameter bypass into the Humber River permits the submerged outlet to be dewatered at any time for cleaning or inspection. An 84-in. diameter sewer has been constructed around the entire plant connecting to the outlet sewer, thus permitting diversion of excessive flows directly to the lake in emergencies.

The length and area of the outlet sewer will give 15 minutes contact time for post chlorination of the effluent, even at maximum flow.

Sludge Digestion and Disposal

The disposal of the solids removed as sludge from the primary and final settling tanks represents a separate and difficult part of the project. Being highly putrescible, this sludge could be a serious nuisance unless its disposal is satisfactorily accomplished. It must be rendered unobjectionable and disposed of rapidly to prevent excessive accumulation; such methods as may be employed preserving economy to the highest degree.

Any treatment to the sludge that excluded digestion could not be practised on the Humber site without the creation of unfavourable odours. Such odours would result in severe criticism from residents in nearby developed areas. In addition, the reduction of solids by 40% and the consequent decrease in the volume of sludge to be handled by later disposal methods, plus the value realized in utilization of sludge gas for power and heating purposes, made digestion in this instance almost mandatory. Through digestion above all else, sludge can be made sufficiently innocuous to be safely distributed in some form for soil rehabilitation.

Estimated sewage strengths predicted that at initial design 96,600 lb. of sludge on a dry basis would have to be pumped to the digestion tanks daily or, at 4.5% solids concentration, 215,000 gal. If solids loadings on the digestion tanks were to be restricted to 2.15 lb. (dry basis) per cu. ft. of digestion tank per month, then approximately 1,400,000 cu.ft. of volume was required.

To meet this requirement, six tanks are now under construction, each 110 ft. in diameter with 25 ft. side water depth. It is reasonable to assume that within 40 days sludge will be reduced in volatile content sufficiently to reduce the daily weight of solids for disposal to 61,000 lb. dry basis, and that this reduction will produce gas at the rate of 581,000 cu. ft. per day, representing heating value of 14,100,000 B.t.u. per hour.

The tank structures have been arranged for two-stage digestion, with the four Primary ones being in a continuous state of rapid digestion while the two Secondary units will permit separation of the sludge under quiescent conditions. Three of the Primaries are equipped with mechanical sludge mixers, the fourth having a gas recirculation system. With this arrangement, sufficient experimentation will be possible to determine if high rate digestion is feasible, in which case the initial tanks will be capable of considerable overload when planning future extensions. All primary tanks are designed with fixed covers, while the secondary tanks are fitted with gravity gas holders that will permit storage of 200,000 cu. ft. of gas at 7 in. pressure.

The tanks are arranged three abreast with a central control gallery. Raw sludge will enter the Primaries through spiral type hot water heat exchanges located in the gallery, and the tank contents will be continually circulated to maintain temperatures between 90 and 95° F. The introduction of raw sludge to the primaries automatically spills sludge from these tanks to the secondary units, from which supernatant liquor overflows to the plant inlet for treatment and from which digested sludge is pumped. Gas generated in each tank is metered and discharged either to the engines or the gas holders, depending on the pressure obtaining in the system. Automatic controls, pressure and vacuum relief valves safeguard the system against explosion.

Digested sludge withdrawn from the secondaries will be pumped with heavy duty plunger pumps through an 8 in. forcemain some 4000 ft. westerly to the existing Etobicoke Sewage Plant, which is to be converted to a dewatering facility as part of the Humber project.

The existing digestion tanks here will be utilized for storage of digested sludge passing through the forcemain mentioned previously, and the existing open tanks will be used for elutriation and sludge concentration purposes. Sludge from the elutriation tanks will be pumped to new vacuum filters for dewatering to 67% moisture content. The filters will receive sludge at the rate of 4.4 lb. (dry basis) per sq. ft. per hour, with application of 3% by weight of ferric chloride for coagulating purposes. Filter cake will be stored in hoppers for daily disposal by trucks to farm lands within a seven mile range. Incineration or heat drying facilities may be necessary on this site at a later date.

Calculations indicate that the disposal of digested sludge by elutriation, filtration, and truck haulage to farms would cost approximately $10.25 per ton (dry basis) including capital and operating charges.

Structural Features

The plant hydraulic structures are reinforced concrete, with design based on standard A.C.I. and National Building Code regulations. Anchors have been used to resist uplift from the relatively high ground water. These are formed of ¾ in. diameter double legged deformed bars, extending 5 ft. into drilled holes in the rock that were slushed full of neat cement grout after setting of the steel. These units were designed to resist a pull of 10 tons, but tests on the finished product have indicated that a pull of 30 tons can be made without failure.

Despite the length of the open tanks, no expansion joints were provided, partly because of the rock anchorage cost and risk of major leakage. As an alternative, temperature steel was increased to 0.5% of the net concrete area: corners, together with construction joints, were specially reinforced, on the assumption that temperature cracks would distribute with even spacing and few would support leakage of measurable amount. This procedure had been followed in some American plants with success.

Leakage tests on the new tanks at the Humber and the crack pattern that has developed have proved the

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THE BEAUHARNOIS NO. 3 DEVELOPMENT

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This paper deals with No. 3 Section of the Beauharnois Development, a project originated in 1929 and now nearing completion with construction of this third and final phase. A property of the Quebec Hydro-Electric Commission and situated some 30 miles west of Montreal, the completed Beauharnois Development will be one of the main sources of power supply for Canada's metropolis.

This submission on Beauharnois No. 3 includes its general features, hydraulic characteristics, evaluation of benefits to be derived from its generating units, general design considerations, equipment characteristics, construction procedure and methods.

ONE SHOULD not merely picture a huge powerhouse when considering the Beauharnois Development. Rather, the project embraces a tremendous development extending over 16 miles of territory, an enterprise involving the control of the St. Lawrence River which, for the first time in history, was dammed over completely for eventual total diversion into a man-made canal.

The Beauharnois Development utilizes the water power available on the St. Lawrence between Lake St. Francis and Lake St. Louis. Three series of rapids cause a drop in level of 82 ft. over a distance of 15 miles. Since the minimum flow of the St. Lawrence at Beauharnois will be maintained above 210,000 c.f.s. during high-load periods on the system, the primary potential power available will be over 1,600,000 continuous horsepower.

River flow is controlled at the outlet of Lake St. Francis by four dams extending across the St. Lawrence between three islands—(Fig. 1). Water is directed into the 15-mile canal excavated on the south shore, and returned to Lake St. Louis following an 80-ft. drop through the powerhouse.

Incidentally, the St. Lawrence River control works and remedial dams were described in detail by the late M. V. Sauer, M.E.I.C., in an excellent paper published in *The Engineering Journal* of December 1943.

The first two sections of the Beauharnois Powerhouse comprise 26 main units of approximately equal capacity (53-56,000 h.p.) and two auxiliary 8,000 h.p. units, providing a total of 1,425,000 h.p. Addition of the third section—Beauharnois No. 3—will increase the installed capacity to 2,161,000 h.p. with the ten units being installed or to 2,235,000 h.p. if a contemplated additional unit be added. The total length of the powerhouse is 2,843 ft.

The average daily production will be over 34,000,000 kwh. by 1961. This production can be appreciated better by comparison with its energy equivalent: a daily train load of coal comprising more than 300 cars of 50-ton capacity apiece!

Hydraulic Characteristics

Construction of the St. Lawrence Seaway and development of power in the International Rapids Section of the St. Lawrence have brought to the fore the opportunity of regularizing available flow. The problem, however, has proven to be very complex because of the multiplicity of conflicting interests. Two countries, the United States and Canada, are involved, with two different Provinces of our country, Quebec and Ontario. As a result, some degree of compromise was necessary to satisfy navigation interests, riparian rights and power requirements. Numerous criteria were suggested to protect all interests as much as possible, and a tentative regulation plan was proposed. This plan would bring the minimum outflow from Lake Ontario, the source of the St. Lawrence, to 190,000 c.f.s. in open water periods, and would limit the maximum discharge to 310,000 c.f.s.

Production of power at Beauharnois is governed not only by flow available in the river but also by the possibility of admitting into the 15 mile intake canal—under adverse ice conditions—the quantity of water required by hydraulic turbines. It is known quite generally that such difficulties have been experienced mainly because the total capacity of units installed increased more rapidly than did the enlargement of cross-sectional areas of the canal—(Fig. 3.) As a consequence, resulting water velocity has been higher than desirable for the formation of a smooth ice cover. Moreover, it happens frequently that frazil or shell ice accumulates in the cooling system of units before ice has consolidated on the surface. This has temporarily impaired normal output.

Considerable progress has been made in recent years in eliminating a substantial percentage of the reduction of power accompanying freeze-up conditions. Such results have been obtained mainly through:

(a). the use of ice booms installed at various strategic locations in the canal to prevent movement of ice sheet in areas adjacent to higher-velocity currents, the booms placed to facilitate formation of an initial ice cover.

(b). the installation of emergency sources of frazil-free water supply—either in the sluiceway adjacent to the plant or in the excavated area for Beauharnois No. 3 powerhouse.

Experience obtained from the latter expedient has contributed valuable information for the design of the cooling-water supply system for the third section of the powerhouse.

Evaluation of Benefits to Be Derived from Units of Beauharnois No. 3 Powerhouse

Beauharnois No. 1 and No. 2 powerhouses experienced serious limitations in power output for several years during ice-forming periods. Accordingly, genuine apprehension was felt about benefits to be derived from investment involved in the third section of the plant. Contributing also to this anxiety was the fact that the reduction in output generally coincided with peak-load periods on the system.

Based on latest information on the probable regulation plan to be adopted for Lake Ontario, a careful analysis was made of energy to be derived from each additional unit of Beauharnois No. 3. Borne in mind were:

(a). Limitations in flow that can be admitted into the canal during the winter season.

(b). Loss of power produced at the Cedars plant—dependent upon the same control works for its water supply—when diversion of flow into the Beauharnois canal does not leave at least 64,000 c.f.s. in the river.

The 95 years of recorded flows of the St. Lawrence were divided into nine 10-year periods, the last five being ignored for statistical purposes and the proposed regulation plan applied through that period.

The average yearly flows in each 10-year period were tabulated in order of magnitude and listed, respectively, as flow available 10%, 20%, 30% and up to 100% of the time. The nine averages were then used as the basis of an overall average yearly flow figure—again for 10%, 20%, 30% and up to 100% of the time.

The monthly distribution of flow, corresponding to the theoretical average yearly flows calculated above, was obtained by comparison with a year of similar flow average under the proposed regulation plan.

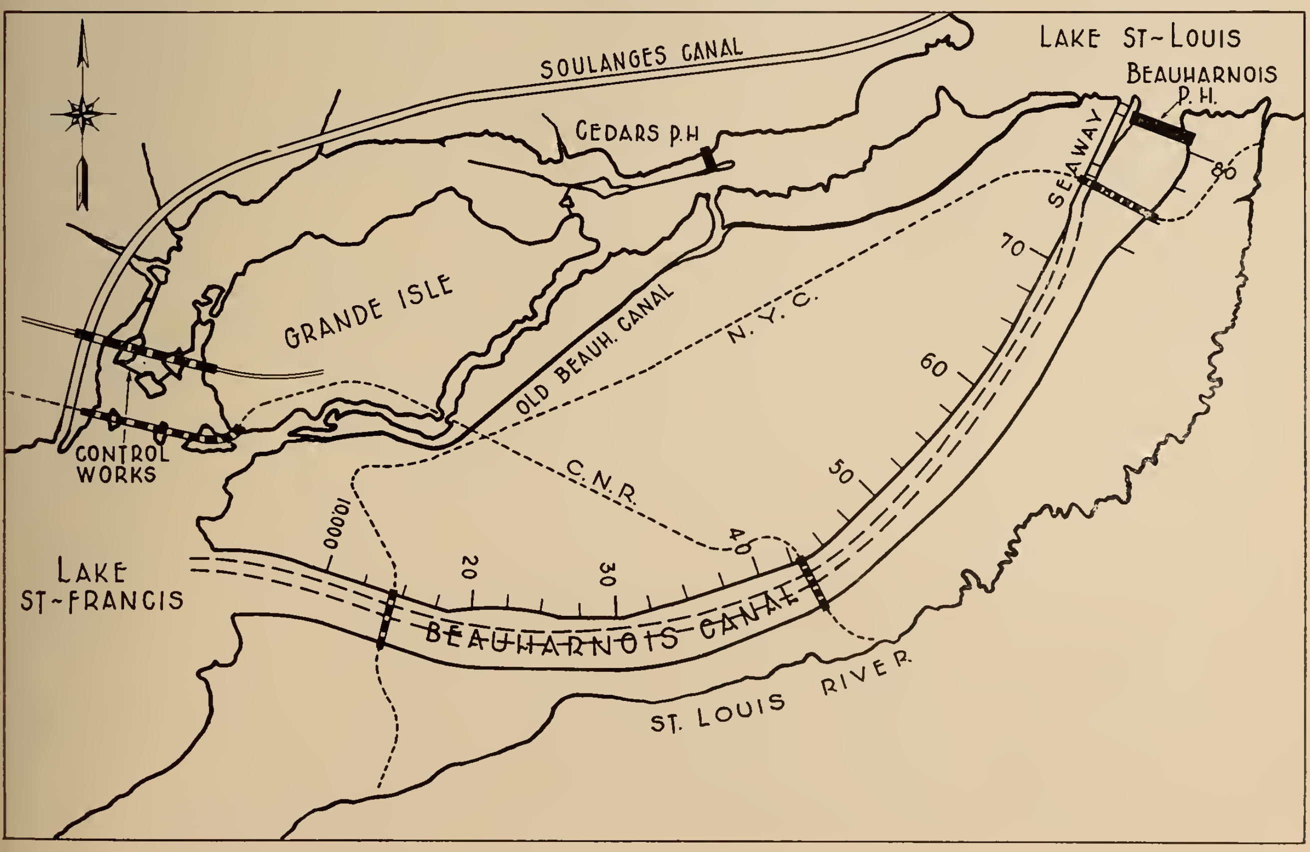
Table I gives the monthly flows used for assessing benefits to be expected during a given percentage of time.

Table II figures have been derived from the flows given in Table I. They show additional energy to be expected from the ten units of Beauharnois No. 3, bearing in mind the limitations previously mentioned.

It is very interesting to note that, considering flows available five years out of ten, the energy production at Cedars during the December 15-March 31 period—after Beauharnois No. 3 is in operation—will still be 57% of what it would have been without Beauharnois No. 3. Moreover, with Beauharnois No. 3 powerhouse in operation, Cedars plant winter production is 84% of its average annual production.

The next very important question was the quantity of firm power to be obtained from Beauharnois No. 3. There has been and still is some doubt

Fig 1. Beauharnois Development



about the number of units that can be utilized during the ice-forming period. Opinions vary from two to four. However, it is quite generally admitted that, after consolidation of an ice cover on the canal, the minimum guaranteed winter flow through the probable regulation plan (210,000 c.f.s.) could be utilized. This involves the first three units of this third section.

It must be borne in mind also that a good proportion of the energy to be available from Beauharnois No. 3 will be used to firm up the production of sister plants. Such plants include the nearly-completed Bersimis development, some 400 miles northeast of Montreal, and the proposed Carillon plant, on the Ottawa River, about fifty miles west of the metropolis. The ratio of average production to installed capacity at these three plants, as indicated in Table III, is less than Hydro-Quebec's annual load factor. In other words, these three stations cannot contract for power—at the usual load factor—to the extent of their installed capacity, unless energy is supplied from another source to counteract the lack of water available.

Other considerations contributed to the decision to install 10 units in Beauharnois No. 3 and provide space for an 11th:

(a). A majority of the 14 units in Beauharnois No. 1 has been more than 20 years in operation, four of them being 27 years old. Moreover, owing to their physical dimensions, the runners were cast in four sections bolted together and they have required more maintenance than conventional one-piece runners. It is usual to take a turbine out for major overhaul every eight to ten years, with an outage period of over three months. Applying the same assumption to turbines of Beauharnois No. 2 and Beauharnois No. 3, it is expected that — with their combined total of 36 units—four could be taken out of operation every year.

(b). Since it would not be economical to transmit reactive power from the Bersimis plants, any additional units at Beauharnois—for which no winter flow was available — could provide a substantial and flexible source of reactive power which would be economically preferable to installation of static capacitors in the Montreal area.

Table I

All Flows in Thousands of c.f.s.

% of Time	Oct.	Nov.	Dec.		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Ave.
10	271	258	256	240	218	256	275	283	290	300	304	303	282	274
20	265	249	242	232	216	246	256	270	278	285	290	293	282	264
30	258	241	240	228	216	240	248	259	271	278	282	284	261	256
40	252	236	238	226	216	236	242	252	265	272	275	276	258	251
50	247	234	236	226	216	233	238	247	259	265	267	270	257	247
60	242	231	234	226	216	231	234	242	253	259	260	262	256	243
70	237	229	234	226	216	228	229	237	244	252	252	254	248	238
80	232	227	232	226	216	225	226	232	234	244	244	246	241	233
90	225	224	226	226	216	220	220	223	224	235	235	234	230	226
100	211	221	222	222	214	215	212	205	212	230	231	228	215	218

General Design Considerations

General agreement was reached on the following limitations in design:

(a). Avoidance of any radical change in architecture or superstructure construction unless a substantial saving—in the order of $1,000,000—would result.

(b). Allowable increase in spacing of units of not more than 10% as compared to existing installation—and no allowance for reduction—on account of required bulkhead stability.

(c). Maintenance of present elevation for roof, bulkhead, generator floor and crane rails.

(d). Permission for a change of plus or minus 4 ft. in turbine floor elevation to accommodate larger scroll cases associated with more powerful turbines.

(e). Retention of alignment of walls.

(f). Since the bulkhead and intake for the first four units had been built already with the powerhouse of Beauharnois No. 2 to provide a tie in the upstream earth dyke, it was agreed not to eliminate the possibility of a different design for the remaining units if the savings resulting therefrom could justify the added inconveniences. However, it was concluded that all ten units should be similar.

The major difference in the design of the powerhouse of Beauharnois No. 3 and the powerhouse of Beauharnois No. 2 lies in the type of turbine and the capacity and speed of units. Beauharnois No. 3 has propeller turbines of greater capacity and higher speed than the Francis-type turbines in Beauharnois No. 2. Consequently, draft tubes, scroll cases and generator foundations are quite different.

Individual hoists for headgates are provided for seven units to permit emergency lowering. Gates had been installed already for the first four units and individual hoists were not provided. Sump and sump pumps have greater capacity and the method of de-watering draft tubes is different.

Table II

% of Time	Annual Energy from Beauharnois I and II, plus Cedars	Annual Energy from Beauharnois I, II and III, plus Cedars	Annual net gain
10	10,454 × 10⁶ kwh	13,227 × 10⁶ kwh	2,773 × 10⁶ kwh
20	10,441	12,948	2,507
30	10,423	12,664	2,241
40	10,401	12,478	2,077
50	10,383	12,282	1,909
60	10,359	12,105	1,746
70	10,323	11,867	1,544
80	10,265	11,625	1,360
90	10,116	11,294	1,178
100	9,942	10,927	985
		Average:	1,832 × 10⁶ kwh

EQUIPMENT CHARACTERISTICS

Turbines Comparative cost studies led to the conclusion that the use of propeller-type turbines — as opposed to the Francis-type turbines in Beauharnois No. 1 and Beauharnois No. 2 —would permit a saving of at least $3,000,000. These turbines have a normal rating of 73,700 h.p. under a 78-ft. head and rotate at 94.7 rpm. Their outside diameter is 252 in. and six blades are bolted to the runner hub. The runners are of cast steel, with a layer of stainless steel over areas more susceptible to cavitation. Flow is controlled through 24 wicket gates. Draft tubes have an H D ratio of 2.62, about the same as for Beauharnois No. 1 and Beauharnois No. 2 plants. The low point of the draft tube floor is at Elevation 24.5, compared to Elevation 34 for units of the first two plants.

Governors Similar to the governors in the Beauharnois No. 2 powerhouse, they are of size adequate to supply sufficient oil to servomotors. It is possible to operate the turbine gates through a complete closing or opening stroke in a minimum of four seconds, with minimum oil pressure of 270 lb. per sq. in. in the tanks and an operating head of 83 ft. The governor head is capable of causing the relay valve to pass oil in the direction to effect a corrective movement of the turbine gates—in consequence of a speed variation of 5/100 of 1%.

Servomotors are provided with adjustable by-pass connections whereby the rate of closure may be retarded during the portion of gate travel, from slightly below speed-no-load position to fully closed position.

Generators Of vertical shaft, water-cooled type, the generators have direct connected main and pilot exciters. With a continuous rating of 65,000 kva at any power factor from 85% to 100% and rated at 13,800 v., their temperature rise does not exceed 60° C in the rotor and stator windings. They are capable of withstanding the runaway speed of the turbine—206 rpm.

The field winding is equipped with non-continuous damper winding, which gives a ratio of quadrature to direct axis subtransient reactance of not more than 1.5. Short circuit ratio is calculated to be 1.11 and exciter response ratio is at least 1.0 as defined by ASA standards.

Table III

	Installed Capacity kw	*Average Production kw*
Bersimis I	900,000	560,000
Bersimis II	625,000	300,000
Carillon (proposed)	625,000	285,000
TOTAL	2,150,000	1,145,000

RATIO: $\frac{1,145,000}{2,150,000} = 53\%$

The flywheel effect of the rotating parts is 78,000,000 lb. ft. squared and the thrust bearing will support 1,987,000 lb., representing the weight of rotating parts and unbalanced hydraulic thrust. Each generator is so constructed that it can be assembled or dismantled with the use of existing 200-ton cranes.

Coolers are so designed that, when operating at rated load, the difference in temperature between air leaving the coolers and water entering them will not exceed 10° C.

The multi-turn stator coils are insulated with continuously-taped Class B material and, by means of a vacuum and pressure process, are impregnated with a thermalastic compound.

The star-connected stator winding has two circuits per phase, distributed around the stator for split-phase differential current protection. It is a double-layer, top-connected, four-circuit winding with alternate poles in series and using three turns per coil.

Transformers, Breakers, Control Transformers are rated 40,000/65,000 kva - three phase - 60 cycles - 13.8/120 kv - type ONS-ONP - 55° rise.

The high-voltage winding is star-connected for grounded neutral system and has additional turns to compensate for regulation at 85% power factor, lagging, full load. Insulation is graded from 650 kv basic insulation level, at the line end, to 110 kv at neutral. Low-voltage winding is delta-

Fig 2. Aerial view—powerhouses 1, 2 and 3

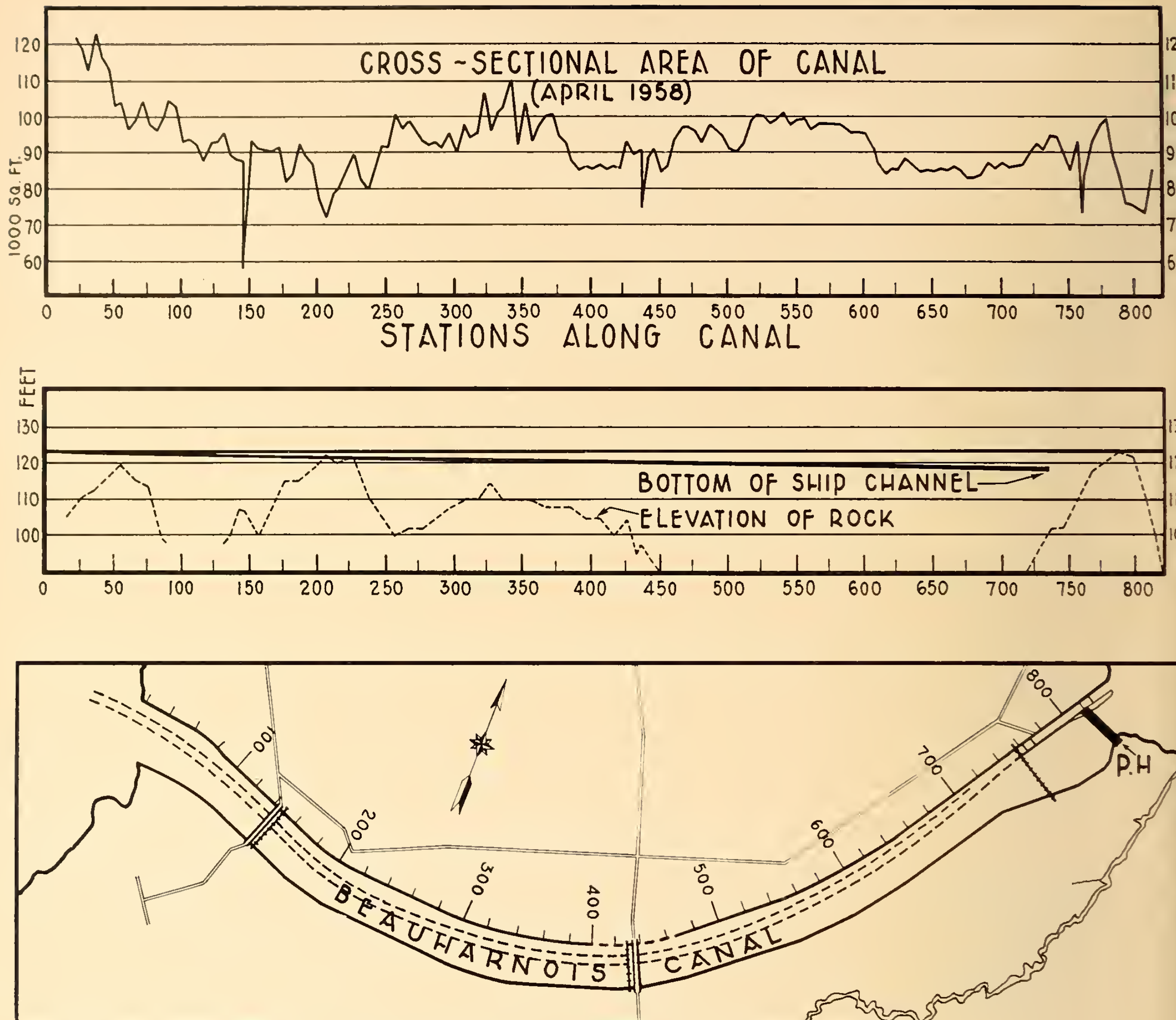


Fig 3. Cross-sectional area of canal

connected for operation on the 13.8 kv system.

Fin-type radiators are installed in groups on both sides of the transformer banks. Axial-flow, air-blast equipment is mounted on these radiators and automatically controlled by the temperature of the hottest spot in the winding.

The tank is of *Shell-form-fit* construction and designed to withstand full vacuum.

Power is taken from these transformers to the switching station near the tailrace through three-phase 5,000 mva oil-circuit breakers.

Control of units can be effected locally through duplex switchboards, each handling two adjacent units, as well as by supervisory means from the main Control Room in the Beauharnois No. 1 powerhouse.

Electrical Supply for Plant Auxiliaries Electrical station service provided for the Beauharnois No. 3 powerhouse consists mainly of:

(a). Two 1,500 kva-13,800 575 v., dry-type transformers which can be fed from two different power sources.

(b). One 575-v. distribution system to supply main auxiliaries.

(c). Six 112.5 kva-575 120 208 dry-type distribution transformers for lighting and convenience outlets.

It might be well to explain the 13,800-v. power supply and the 575-v. switchgear and distribution.

13,800 v. power supply. One of the sources of supply for plant auxiliaries is a 13,800-v. station service ring bus. Located in the Beauharnois No. 1 plant, it has supplied station service requirements for the Beauharnois No. 1 and Beauharnois No. 2 plants. The second source is a tap connection installed between two units, Nos. 23 and 24.

To simplify protection and prevent faulty operation, it was decided that the transfer from one source to the other would be performed manually. On the basis of previous experience in the Beauharnois No. 2 powerhouse, it is estimated that the units in the Beauharnois No. 3 plant will be able to operate from 20 to 30 minutes without station service power. That period of time should be sufficient to permit manual transfer.

This ring bus has proved a reliable system. It can be fed from two 7500 kva auxiliary units or from any other main unit from No. 1 to No. 16 inclusive. The present station service load is approximately 5,000 kva and, with the addition of the Beauharnois No. 3 powerhouse, it should not exceed an average of 6,000 kva, which is less than the capacity of one auxiliary unit. An extensive scheme of protective relays was completed recently on the ring bus so that defective equipment may be cleared in minimum time and with the least interference with plant operation.

Since physical and economic considerations dictated the use of power-cable connections to supply auxiliary power in the Beauharnois No. 3 plant, and because of the possibility of failure of cables and associated equipment, it was decided that the importance of such service justified a duplicate source of 13,800-v. power. Incidentally, the tap connection was installed between units No. 23 and No. 24 because of space available for tap-off equipment and because of existing provision in the isolated phase bus of these units.

575-v. Switchgear and Distribution — An air circuit breaker in the secondary of each transformer is connected to a main bus, sectionalized by a tie breaker. Six main feeders are connected to this main bus, three on each side of the tie breaker. Normally, each transformer will supply one-half the station service load. Should a fault occur in one of the transformers or in its 13,800-v. source, causing a marked decrease in voltage, the secondary breaker on the faulted transformer will open automatically. Following this action, the tie breaker will close, thus transferring the entire powerhouse service load to the other transformer.

A similar throw-over feature is included in each of the six distribution cubicles receiving power from two 1000-amp. bus ducts connected to one of the three feeders on each side of the above mentioned tie breaker.

Service Water System

An effort has been made to save the Beauharnois No. 3 powerhouse from the difficulties experienced by its allied units through frazil-ice blockage of the cooling water supply to generators and bearings. Success will mean improving the dependability of the system under all climatic conditions.

Essentially, the service water system must be planned so that piping, strainers and pumps are designed to provide an adequate flow of filtered water at prescribed pressures. It consists of four main component parts:

(a). Raw water intakes and header;
(b). Strainers;
(c). Filtered water headers;
(d). Fire protection and high-pressure system.

Raw Water Intakes and Header — The raw water header is a 16-in. pipe line, extending the entire length of the powerhouse. Its main purpose is to serve as a collector for the raw water intakes and divert it to strainers and other feeds.

Unlike previous installations, there are two different types of raw water intake. One consists of a standard 12-in. intake with a rough metal grid strainer and originating in the scroll case of each unit. Similar to the intakes installed in the Beauharnois No. 2 powerhouse, they have a capacity of approximately 7500 gpm at 20 psig and under operating conditions.

The second type consists of a 16-in. pipe extending along the side and near the bottom of the main water intake passage of units No. 31, No. 35 and No. 36. It is estimated that each of these intakes will have a capacity of some 10,000 gpm at 20 psig under operating conditions.

This second type of intake was installed to provide a source of water free from frazil ice during the winter months. During that period, cold air temperatures, winds, and water velocity in the power canal and open-water areas cause ice particles to be formed. These particles are carried in a state of suspension in water, their density varying from light to slush ice.

This frazil ice creates two problems in the water system. First, should the concentration be appreciable, it will clog the rough strainer at the intakes. Secondly, if the ice particles are much diluted in water, they will enter the water system and accumulate in the main water strainers which have a mesh of 12 x 12 x .022. The result in both cases is that a serious water shortage develops, impairing the cooling system.

Location of openings for the auxiliary intakes was selected on the basis of frazil ice soundings and the absence of icing conditions at the lower section of the trash racks. Sounding records indicated a negligible concentration of frazil ice at depths greater than 27 ft. On the basis of these findings, the above mentioned intakes were located at Elevation 101.3 — water surface elevation in the winter being 148.0 - 149.0 — and as near the bulkhead as possible.

Strainers — Three banks of strainers have been provided. One bank of two strainers is located between units No. 28 and No. 29, another of three between units No. 30 and No. 31, and space has been provided for a future bank of two between units No. 34 and No. 35. Each strainer has a capacity of 4300 gpm with a water head loss of 5 ft. Greater volumes can be obtained with correspondingly larger head losses and a lower degree of cleanliness.

Filtered Water Headers — Two 16-in. pipe lines are provided to distribute the filtered water at approximately 18 psig from the strainers to the unit cooling systems, fire pumps and accessories. Both of these headers will be interconnected with similar pipes in the Beauharnois No. 2 powerhouse. One of the headers extends into the Beauharnois No. 3 powerhouse to the second bank of strainers located between units No. 30 and No. 31. The other header extends the entire length of the powerhouse. The flow of water through these headers varies with climatic conditions, but approximately 13,000 gpm will be used by this powerhouse on an average summer day. The main feeds are the unit-cooling systems, each requiring 1000 gpm for generator cooling and 100 gpm for bearings.

Fire Protection and High-Pressure System — These headers are used mainly for sprinkler feeds to the units, flushing of strainers, compressor after-coolers, hose connections, deluge valves for mulsifyre systems on transformers and breakers, etc. . . .

Total water-cooling requirements, exclusive of protection needs, amount to over 20,000 gal. per min. for the Beauharnois No. 1 and Beauharnois No. 2 powerhouses, and to over 10,000 gal. per min. for the Beauharnois No. 3 plant.

Equipment Protection — Depending on type of fault, the following operations may take place:

(a). An alarm or signal will be given.

(b). The high-tension circuit breaker will open, the generator continuing to operate at speed-no-load.

(c). A multi-contact relay will cause high tension and field breaker to open, with the governor closing turbine gates and brakes bringing the unit to complete rest.

An alarm will ring, causing the irregularity to be indicated on an annunciator board under the following circumstances: whenever a ground develops in the stator winding or in the field circuit of the exciter or generator; whenever an abnormally high temperature is detected by thermal elements in the windings, bearings and oil wells.

The high tension breaker will open, with the generator operating at speed-no-load, whenever one of the following situations arises: an overload on the transformer accompanied by a voltage drop, an over-voltage on the unit, a 5% over-speed of the unit or a fault detected by bus differential relays.

The multi-contact relay will operate, bringing the unit to rest, whenever there is an unbalance in the split-phase circuits of the generator or in the current between generator and transformer; an overload in the generator accompanied by a voltage drop; an over-speed of 125%; high bearing temperature detected by thermometers; low oil pressure in the governor system; or formation of gas in the transformer tank.

Powerhouse Outgoing Lines — The output of units No. 1 to No. 22 inclusive—except for five or six generators used on local 13.2 and 44 kv systems—is directed to a switching station near the Beauharnois No. 1 tailrace by means of ten 115 kv lines, while the production of units No. 23 to No. 36 inclusive is fed into another switching station near the Beauharnois No. 3 tailrace by means of seven 115 kv lines. The two switching stations are interconnected by two 115 kv lines of 795,000 C.M., crossing the forebay.

From these two switching stations — of the double bus and transfer bus type — power is transmitted to the Hydro-Quebec system in and around the Montreal area.

We have attempted to outline problems encountered in realization of Hydro-Quebec's Beauharnois No. 3 project, and the measures taken to arrive at what we expect to be the best solutions.

Construction aspects of this development

The project was approved in the summer of 1956, the schedule calling for four units to be delivering power by the fall of 1959. Scanning the amount of work to be done in a short period of three years, no one can deny that this was a very tight schedule. The general contractor came in the field on August 1, 1956.

Table IV will give an idea of the huge quantities of materials and equipment we had to handle.

Table IV

1—*Excavation*	Earth in forebay	225,000 cu. yds.
	Earth in powerhouse and tailrace	165,000 cu. yds.
	Rock in powerhouse and tailrace	1,265,000 cu. yds.
2—*Dykes*	(a) *New Dyke*	
	Stripping borrow pits	15,000 cu. yds.
	Earth excavation	140,000 cu. yds.
	Rock excavation	200 cu. yds.
	Foundation Preparation	
	On rock	23,000 sq. yds.
	Under clay core	10,000 sq. yds.
	On natural ground	8,500 sq. yds.
	Rock fill	219,000 cu. yds.
	Impervious clay core	117,000 cu. yds.
	Transition material	108,000 cu. yds.
	Sand filter	13,000 cu. yds.
	Gravel	2,000 cu. yds.
	Overhaul	150,000 ton-miles
	(b) *Old Dyke*	
	Removal	1,000,000 cu. yds.
3—*Cofferdam*		141,000 cu. yds.
4—*Concrete*		220,000 cu. yds.
	Contact forms	1,440,000 sq. ft.
	Rock preparation	26,000 sq. yds.
5—*Reinforcing*		8,000 tons
6—*Structural Steel*		1,200 tons
7—*Bricks*		1,200,000 units
8—*Glazed Tiles*		250,000 units
9—*Floor Finish*		265,000 sq. ft.
10—*Units*	10—plus space for one additional	
11—*Head Gates*	14—each with its individual hoist (two per unit)	
12—*Trash Racks*	44—(four per unit in two sections each)	
13—*Draft Tube Gate, permanent*	two sets (four gates) steel. In addition, three sets of concrete stop logs for construction purposes.	
14—*Highway Bridge over Tailrace*	five spans of 90 ft. apiece four lanes four concrete piers of 45-ft. height	

Construction Services

There is nothing out of the ordinary about these services. An electrical substation was built with the necessary distribution facilities . . . fire protection facilities were installed where required . . . various buildings were re-adapted from Beauharnois No. 2 construction for stores, offices and shops for machinists, carpenters, pipefitters, electricians and other tradesmen . . . quite an elaborate heating plant and distribution facilities were made available for winter concreting.

Incidentally, the main pieces of construction equipment will be mentioned as we go along.

Cofferdam

Since the Beauharnois plant is not being built directly across the St. Lawrence River, there is no water diversion problem. Nevertheless, it was necessary to build a cofferdam to permit excavation of the tailrace in the dry. To meet schedule requirements, construction of the cofferdam had to be started in winter. The starting and completion dates were February 1 and July 2, 1957, respectively.

Located in the practically still water of Lake St. Louis, this cofferdam was built as a rock-fill dam with a clay blanket and rip-rap. This procedure proved to be much cheaper than the regular crib work used for Beauharnois No. 2.

The quantities involved were:

77,000 cu.yds. of rock from the powerhouse and tailrace excavation;
26,000 cu.yds. of gravel from the disposal of canal dredging;
30,000 cu.yds. of impervious material from the nearby borrow pits used for construction of the main dyke;
9,000 cu.yds. of rip-rap.

A 6-cu.-yd. Marion dragline did removal work in less than six weeks — November 10 to December 20, 1958.

It took some two weeks to remove the 25,000,000 gal. of water from the cofferdam by means of one 18-in. pump with a capacity of 8,300 gal. per min. and two 6-in. pumps with a capacity of 2,000 gal. per min. each. Working only part time, one of these 6-in. pumps kept the excavation dry thereafter.

Excavation

The Beauharnois Development sits on Potsdam sandstone, the worst property of which is its abrasiveness. Our experience during construction of Beauharnois No. 2, together with much study, decided us to use the oldest type of drilling equipment — the churn drill — for the main part of this particular work. The drilling required nearly 18 months.

Table V shows equipment and results obtained:

Some 943,000 lb. of nitrone and forcite 40% and 75% were used — the equivalent of 0.74 lb. per cu. yd. of solid rock. Short-period blasting caps were used, with periods from zero to 20.

Two 2,800 c.f.m. stationary air compressors supplied compressed air. One 3½-cu. yd. diesel shovel and one 5 cu. yd. electric shovel loaded the blasted rock into 10 dump trucks of 30-ton capacity, with a number of 2 and 2½ cu. yd. shovels being used also from time to time.

Disposal was made into Lake St. Louis for two purposes:

1. To provide the foundation for a new substation;
2. To increase the break-water required between the outlet of our tailrace and the outlet of the Seaway canal.

Grouting

Since the rock was almost horizontally stratified, the only treatment given was a little curtain grouting along the upstream face of the bulkhead, extending to a depth of 40 ft. Following excavation, the rock preparation consisted of removing loose pieces — they were plentiful in some places — and cleaning. The site was ready then for concrete to be poured.

Aggregate

No sand suitable for concrete had been found in the immediate vicinity during construction of Beauharnois No. 2 (1949-52) or during erection of Beauharnois No. 1 (1929-32). We encountered the same problem and duplicated the practice of making sand from the rock excavated at the same time as the crushed stone.

Contractors for the Seaway were preparing to build the Beauharnois Locks at that time. One company was required to supply all the contractors with all the aggregates needed for some 600,000 cu. yd. of concrete. The concrete for our smaller-sized walls and slabs demanded an aggregate whose maximum size was smaller than what the Seaway required. But we reached an agreement with this contractor whereby we were supplied with the full amount of every size required.

Batching Plant

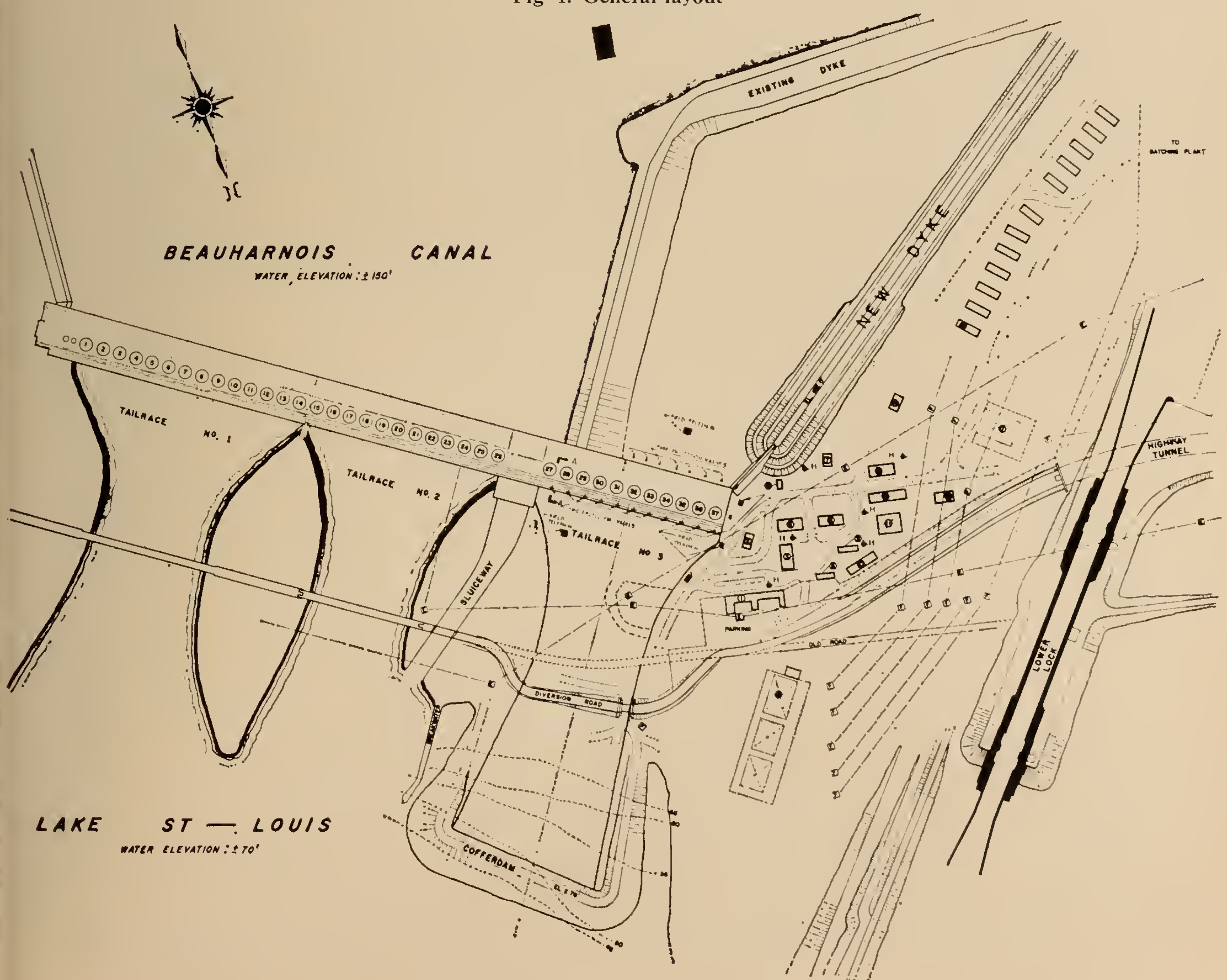
The aggregates were dumped into the supplier bin close to the crusher's stock piles. A conveyor took them from there to four compartments of a silo atop our batching plant. Two of these compartments had a capacity of 90 cu. yd. each, while the other two were of 116-cu. yd. capacity each. A fifth compartment — of 500-barrel capacity — was used to handle the cement to the weight

Table V

Equipment	*Size of bit*	*Drilling speed in ft. per hour*	*Footage drilled between sharpening*	*Footage drilled per bit*	*Total drilled*
4 churn drills.....	9 in.	4 ft.	8 ft.	592 ft.	46,500 ft.
2 Joy Challenger..	3½ in.	15 ft.	12 ft.	141 ft.	180,000 ft.
4 wagon drills....	2 in. and 1½ in.	25 ft.	16 ft.	+120 ft.	506,000 ft.

The maximum depth of excavation was 80 ft.

Fig 4. General layout



batcher, on which every size of aggregate was weighed also.

Bought in bulk, cement was delivered by truck from Montreal — a distance of some 30 miles — and placed in four silos. Two of these silos could handle 3,500 bags each and the other two had a capacity of 4,180 bags each. A special pump transferred the cement from these silos into the batching plant.

Our batching plant, incidentally, was built to accommodate four tilting mixers of two cu. yd. capacity. For this particular work, however, only two were installed, giving us an average production capacity of 80 cu. yd. an hour. This production could be increased to 100 cu. yd. per hour at peak.

Straight Portland cement was used, with an admixture to provide good plasticity and an air-entrained content of 3% to 5%.

The 28-day strength resistance was specified at 3,000 p.s.i. and was obtained by using 400 lb. of cement per cu. yd. of concrete when 3-in. aggregates were used. Once mixed, the concrete was discharged into a 12-cu. yd. hopper under the mixers.

Placing Concrete

Seven 15-ton autocar trucks, equipped with special boxes, brought the concrete from the hopper to the form work of the powerhouse. The hauling distance was less than one mile and the concrete was dumped into 3-cu. yd. laydown buckets. 2-cu. yd. buckets were used when the reach was too far for the equipment.

Placing equipment to handle these buckets comprised:

- One 15-ton truck crane;
- One 45-ton truck crane;
- One 15-ton stiffleg derrick on rails;
- Two twin-boom Gantry cranes of 6-ton capacity each at 100 ft. radius;
- A number of two and 2½ cu. yd. cranes.

For the last six scroll cases and generator piers and slabs, the powerhouse structure being built, crane and derricks from the outside are not practical, so we have gone to pumpcrete; but on account of harsh aggregate, to allow the concrete to flow through the pipe we are obliged to increase the cement content.

With that we are succeeding, but we have noticed that the abrasiveness of the aggregate is causing the pipe to wear very fast, and even with more cement we experienced delays due to plugged pipe, so we are using the overhead cranes of the powerhouse —when they are available—to place the concrete brought inside the powerhouse from the downstream bridge through a window.

All pours have been what might be termed small lift. The largest pour per unit was 1,700 cu. yd. with 1,200 cu. yd. as the second largest and the remainder under 800 cu. yd.

Formwork

With small lifts, there is no necessity for very heavy forms. We use small panels of 2 ft. 8 in. by 8 ft., made of a 2 in. by 6 in. frame and sheathed by ¾ in. plywood.

The walers were made of two — 2 in. x 8 in. and the steel tie rods were ⅝-in. The limit of rising speed was 4 ft. per hour for a temperature of 55°F. It should be explained here that we worked all year round, a circumstance that called for protection and heating during periods of freezing weather.

Such non-straight forms as the intake and draft tubes were of the dismantling type, the heaviest piece weighing five tons. Three sets of forms were built for the seven intakes and two sets for the 11 draft tubes.

Reinforcing Steel

The 8,000 tons of reinforcing steel were bought in lengths and sizes varying from 40 to 65 ft., with diameters ranging from ¼ to 1½ in. A bending machine shaped these straight bars to requirements. We used an average of 72 lb. per cu. yd. of concrete.

The Building

As explained earlier in this paper, Beauharnois No. 3 is the same type of building as No. 1 and No. 2. Such a heavy structure as Beauharnois No. 3 is needed to support two 200-ton cranes which handle rotor and shaft weighing 350 tons.

The usual procedure was followed for erecting steel and for laying brick and tile. Part of the brick, incidentally, was laid in winter time.

Powerhouse Handling Equipment

Our studies indicated that three 200-ton overhead cranes, already in use in the powerhouse, would be sufficient for the 39 units as far as maintenance was concerned. This was not really enough, however, for the construction period. Nevertheless, by scheduling the heavier lifts as accurately as possible, we proceeded with the work without too many difficulties and two much delay.

Three 150-ton gantry cranes were available on the bulkhead and no additional cranes were required because seven of the new units were equipped with individual hoists.

Trash Racks

As indicated on the cross-section, the Beauharnois powerhouse had no room for emergency gates or stop-logs. To meet any eventuality, the trash racks are designed to be sheeted — if necessary — to function as stop-logs. This is the reason they are so bulky. The opening at the racks is 1.8 times the opening of the gate, while the spacing of the cross bar is 6⅜ in.

Draft Tube Gates

Beauharnois No. 1 and No. 2 have the same draft tubes and the same draft tube gate-openings. Two sets of steel gates are used when repairing turbines in these two sections.

Sizes being different in Beauharnois No. 3, two other sets of draft tube steel gates were provided. Due to the schedule, however, two additional sets of concrete stop-logs were precast to permit work on four units at the same time. A third set was poured last January, as a result of which we are working on five units to have four of them completed during the Fall of 1959 and a fifth early in 1960.

Trashway

A small trashway — with a 4 ft. by 12 ft. overflow-type gate — had been provided in Beauharnois No. 1 on the east side of the units and was operating well.

After construction of Beauharnois No. 3, it was found that — with a 2,100-ft. bulkhead — trash was not all going to the east end. It was necessary to build a similar trashway at the west end of Beauharnois No. 3.

Tailrace Bridge

It was necessary to build a bridge over our tailrace as part of No. 3 highway between Montreal and Valleyfield. A boulevard at present links the town of Beauharnois with the suspension bridge spanning our Beauharnois No. 1 tailrace. A bridge of similar width — 28 ft. — also spans our Beauharnois No. 2 tailrace and spillway channel.

The Seaway Authority constructed a boulevard tunnel to connect with a Boulevard on the Melocheville side, while the Quebec Department of Roads was contemplating additional bridges over No. 1 and No. 2 tailraces. We were asked to build a four-lane bridge with a minimum width of two 22-ft. lanes separated by a 4-ft. curb. Another requirement was a 4½ ft. sidewalk on the downstream side.

The location of this bridge is such that we were not able to make it straight. A 3° 13′ 15″ curve was used. The piers were placed parallel to the flow on the curve of the road. The four welded girders per span were set on the tangent to the curve at mid span, while the floor beams, parallel to the piers, were placed on the girders with their ends on a straight line for each individual span. The floor beam overhang off the girders varies all along the bridge.

This bridge has five spans of 90 ft. apiece. They rest on piers 45 ft. high, 49½ feet long and 5½ ft. wide. The bridge was opened to traffic at the end of May 1958.

Forebay and Dyke

When Beauharnois No. 1 was built —up to and including Unit No. 14— the bulkhead of Units Nos. 15 to 18 was constructed to serve as an end wall to the west dyke of the canal. The eight head gates of these four units were put in place and the clay of the dyke rested against them. These gates were of the upstream skin type.

The same type of construction was used for Beauharnois No. 2. Four additional bulkheads were built with the same kind of dyke, a rolled fill clay protected by 3 ft. thick rip-rap on the water side. Since the gates were of the downstream skin plate type, a row of sheet piling was placed immediately upstream of them. Such construction offered no difficulties, with plenty of clay and with easy and cheap removal by means of our huge suction dredges.

With less clay available, no dyke to be removed later and no bulkhead needed for further extension, a completely different design was made for Beauharnois No. 3.

A concrete wall, acting as a dam, was built from the west end of the bulkhead towards the southwest. However, instead of having a cross wall with contreforts against which the dyke would butt — as on the east side of Beauharnois No. 1 — this wall was extended to be enclosed by the end of the dyke. This dyke was of the rolled fill clay core type, flanked by quarry-run rock from the tailrace excavation.

A row of drilled holes, extending 20 ft. under the upstream part of the clay core, was grouted to guarantee the water tightness of the rock. A wooden spillway was built to fill slowly the pond between the new dyke and the old one from Beauharnois No. 2. Some 300,000,000 gal. of water passed through the spillway.

Why did we proceed this way? There are three reasons:

1- To enable us to check the watertightness of our head gates;
2- To prevent any sudden pressure on our clay core dyke;
3- To permit control of the water in case of trouble.

The operation required five days — September 19-24, 1958. Subsequently, the 16 ft. by 16 ft. concrete slabs on the slope of the old dyke close to the powerhouse were removed by a crane, the 3-ft. thickness of rip-rap having been removed previously by a 6-cu. yd. dragline. In October 1958 the *Hydro-Quebec*, our 36-in. suction dredge, started to extract 400,000 cu. yd. of the 1,000,000 cu. yd. required and to clean that portion of the intake up-stream of the sheet piling which was against the gates. To help in this delicate work—there are four openings 13 ft. wide per unit —a monitor jet was used from the dredge and from the bulkhead to dislodge part of the hard-tamped clay. The remaining 600,000 cu. yd. are to be removed in the early summer this year.

A problem confronted us at the juncture of the Beauharnois No. 2 dyke and the original dyke. Since the old dyke comprised two small dykes with hydraulic fill between, we were obliged to drive six cellular cells linked together to assure stability. These cells were of 645 A7 steel sheet piles. They were removed only by the use of a very strong pile extractor and jet. Even with that, one of them remained in place. This removal task was completed in October 1958.

HUMBER SEWAGE TREATMENT PLANT *(Continued from page 63)*

wisdom of selecting the alternative procedure.

The digestion tanks were designed on normal ring tension procedures, and tenders invited on this basis. An alternative design for prestressed tanks was prepared, however, and reductions in price requested from tenderers if they desired to utilize this method. However, no interest in the alternative was shown.

Practically all superstructures incorporated standard design of structural steel, with only the blower room of the main building requiring special treatment since it embodies an 85 ft. span on a clear height of 45 ft., and must be equipped with a 10-ton crane operating at relatively high speeds.

Construction Progress and Costs

Project work commenced in September 1955, with award of the first rough grading contract, which was followed one month later by award of a second contract covering the shore section of the plant outlet sewer. In the spring of 1956, operations began on the final rough grading contract after homes in the southwest portion of the site had been demolished. All preliminary grading and the shore section of the outlet were finished by fall 1956.

Immediately after completion of the above work, contracts were signed for the supply and installation of return sludge pumps, for the effluent flushing pumps, and for supplying and installing air blowers, gas engines and auxiliaries.

In January 1957, the first general contract was awarded for construction of sedimentation and aeration tanks and related structures at the cost of $5,837,000. About the same time, arrangements were made for the supply and delivery of primary tank collector mechanism and of final tank mechanisms. The first general contract was completed in May 1959.

In January 1958, the contract was awarded for construction of the main building, digestion tanks and related structures.

Three sets of tenders remain to be invited, covering the supply and delivery of vacuum filter equipment; the general contract for construction of the dewatering building; conversion works at the Etobicoke Plant; and the placing of the outlet sewer beyond the shore line of Lake Ontario.

The Humber Sewage Treatment Plant is scheduled for operation before the spring of 1960; and the final cost, inclusive of lands, engineering and contingencies, will be in the vicinity of $17,500,000.

Construction commitments require that the Trunk Sewer Program at present underway along the Humber Valley be completed simultaneously with the plant.

A GAS TURBINE POWERPLANT FOR LOCOMOTIVES

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Some of the gas turbine locomotive developments are reviewed in relation to operating experiences in various parts of the world.

In the light of this experience and of some of the characteristics of operation in Canada, certain lines of development seem in one or more respects to be attractive. In particular, it appears to be important to determine the practicability of relatively high power mechanical transmission. It is desirable for most types of railway service to evaluate a prime mover with better part-load fuel economy than is normally attained by the simple gas turbine, and a low idling consumption is essential.

These questions are examined and proposals are made

EVEN BEFORE the wartime advent of the aviation gas turbine, there was a good deal of interest in the possible application of this form of prime mover to railway use. In spite of the possible problems of noise and the difficulty of competing in fuel economy with the diesel engine, there has always been a strong incentive to reduce the number of rubbing parts and the whole lubrication requirement.

The comparatively recent availability on the market of a variety of excellent aviation engine materials and of improved cooling techniques greatly improve the performance possibilities of the gas turbine. This, in conjunction with the acquisition of design and operating experience in several places, is attracting steadily increasing attention.

This paper is intended to describe some of the advances and to set out certain developments which appear to make the gas turbine a potentially advantageous choice of machinery for locomotive use in Canada. The start of the present work owed a good deal to the encouragement of the late Mr. W. A. Newman, then Chief of Motive Power and Rolling Stock of the Canadian Pacific Railway, who laid great stress on the operating advantage of securing markedly increased power during severe winter conditions. This characteristic distinguishes the gas turbine from the steam or diesel engine. We have since had a great deal of assistance from both the Canadian Pacific and Canadian National Railways, especially information and guidance concerning operating conditions, some of which seem to be little known outside railway circles.

Existing Gas Turbine Locomotives

Table I lists locomotives which have been manufactured or definitely proposed so far. Of those listed a few have not gone past the design stage, but the total operational service of all the units built so far is becoming significant and is sufficient for a preliminary assessment.[1,4,5] It is worth noting that the first gas turbine locomotive operated in Sweden and consisted of a diesel engine exhausting into a gas turbine with mechanical transmission. The second locomotive was constructed by Brown Boveri and went into use on the Swiss Federal Railways in 1941. It employed electrical transmission very similar to that developed for diesel locomotives, and was dismantled in 1954 after it had covered about 230,000 miles.

The Sigma Renault development in France[2,3] makes use of a GS-34, S.I.G.M.A. free piston gas generator and incorporates a mechanical transmission (Fig. 1). Both of these features appear to be giving satisfactory service, and the Renault Company have followed this development with two or more locomotives similar to the first but of twice the power. One of these was expected to be in service before the end of 1958.

British operating experience has been related to two gas turbine electric locomotives, which started operation in 1952 and have accumulated about 300,000 miles each. In many ways they have proved suitable, but the over-all efficiency has been disappointingly low — less than 7% at the rail.[4] One of these, a Brown Boveri locomotive, has a heat ex-

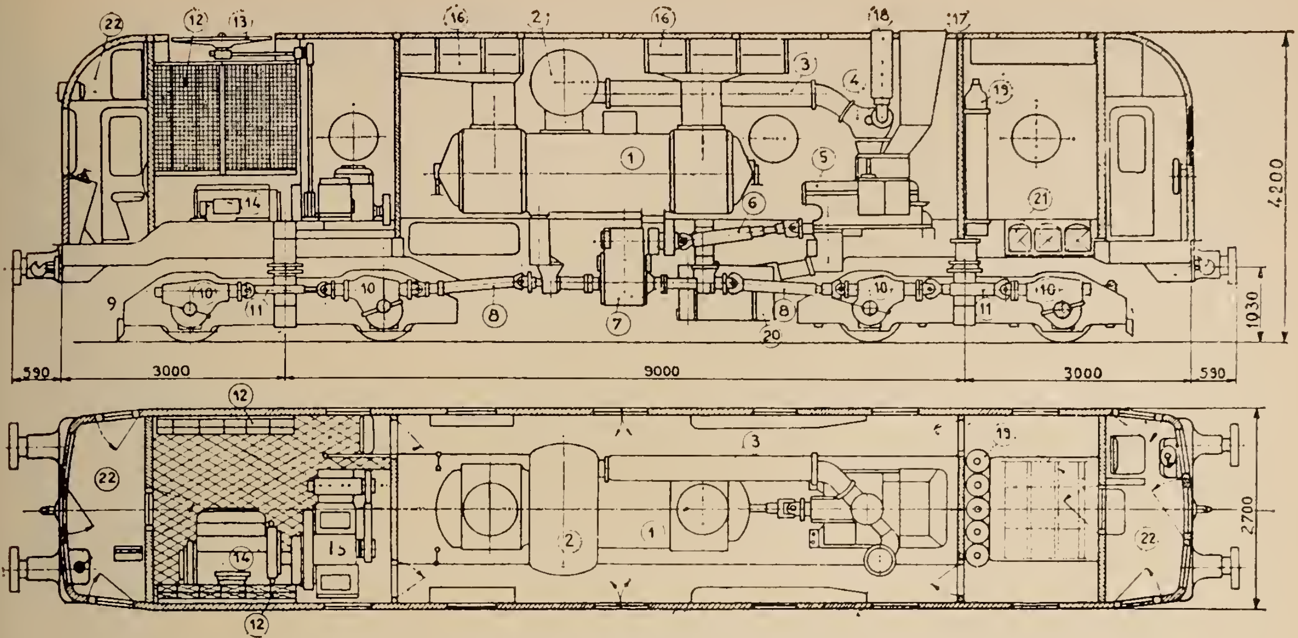


Fig. 1. Sigma Renault 1000-H.P. gas turbine locomotive (Free piston gas generator)

changer incorporated in the cycle but experienced some trouble from coking and subsequent fire, with the result that much of the service has been without the heat exchanger in operation. This locomotive is still in service between London and Bristol, but the other locomotive, of Metropolitan Vickers manufacture, was withdrawn from service rather more than a year ago.

By far the most extensive operational experience has been gained in the United States[5, 6, 7] where 25 locomotives manufactured by the General Electric Company, each developing in excess of 4500 h.p., have been in regular service since 1952 on the Union Pacific Railroad between Ogden and Cheyenne (Fig. 2). The generally satisfactory performance of these engines is attested by the fact that in 1957 the same railway placed an order for 15 additional gas turbine locomotives developing 8500 h.p. each, five of which are now in service.

In 1952 the Westinghouse Company also built an experimental locomotive with two turbines, developing a total of 4000 h.p. Extensive trials with both the Westinghouse and the General Electric locomotives were made on various United States railways in different types of service, but only the Union Pacific Railroad has extended the use beyond experimental service. It appears that the road and traffic conditions are ideally suited to the gas turbine locomotive characteristics, that is to say, there is a long haul at steady maximum load conditions, with the result that the turbine locomotives show to advantage in fuel economy and the maintenance costs. [6, 7]

In Sweden a second engine was built in 1954 using a two-stroke diesel engine as a gas generator with mechanical transmission: this engine has now accumulated 120,000 miles. In Russia a 1000-h.p. free-piston turbo-electric locomotive has been in service since 1956, and Czechoslovakia put into service in June 1958 a 3300-h.p. gas turbine locomotive, with mechanical drive to two three-axle trucks.[5]

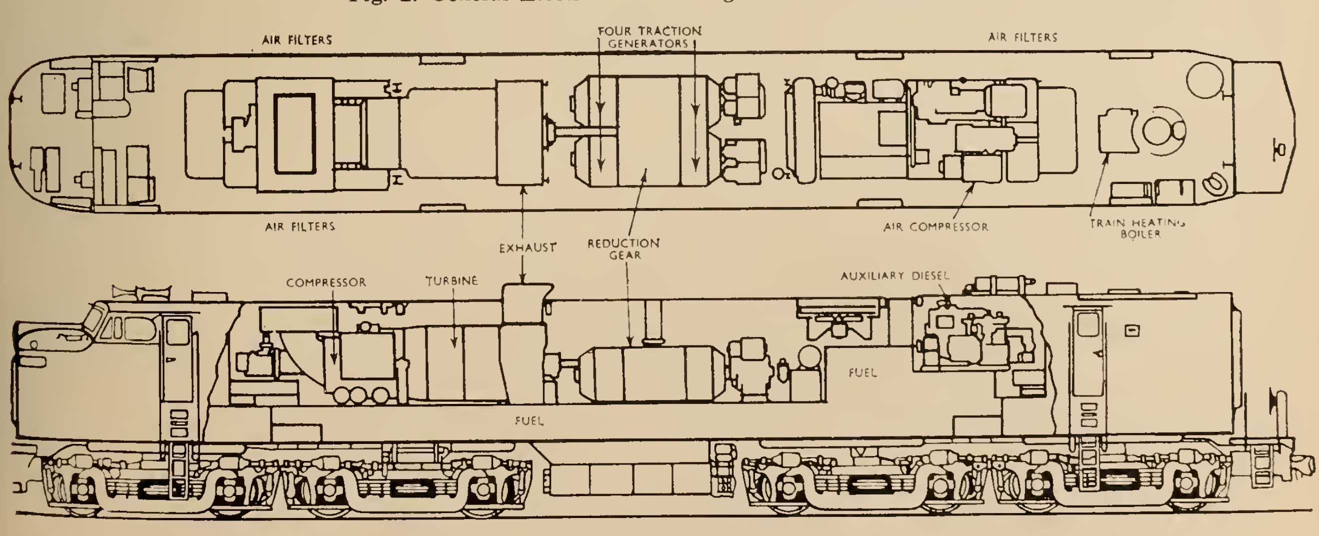


Fig. 2. General Electric 4500-H.P. gas turbine locomotive.

This unit incorporates a recuperative heat exchanger and is reported to be giving satisfactory service.

The Russian State Railways have also been experimenting with gas turbine locomotives of single shaft axial compressor and free piston compressor design.

In view of the difficulty of rivalling the thermal efficiency of the diesel engine except by using free piston gas generators, considerable attention has been directed to the possibility of burning cheaper fuel in the gas turbine than is digestible by a reciprocating engine.

Special reference should be made to developments aimed at the utilization of coal for locomotive gas turbines. Work sponsored by the Locomotive Development Committee in the United States with directly fired coal encountered severe blade erosion.[5, 8, 9] Although progress was being made in separating the ash, the work was suspended in 1958. In order to avoid ash erosion troubles, an indirectly fired coal burning arrangement has, since 1948, been examined at McGill University in Canada[10] and jointly by the C. A. Parsons and North British Locomotive Companies in Britain.[11, 12, 13] The latter project is well advanced and a prototype locomotive is nearly ready for preliminary trials. While the indirectly heated cycle removes the erosion problem from the turbine, it places a somewhat arduous demand on the heat exchanger which, for high power, becomes difficult to accommodate in the usually available space.

Mechanical Drive

In the diesel locomotive, the capabilities of a high efficiency prime mover are commonly matched to the starting and running demands through the intermediary of an electrical transmission system. Such an arrangement, employing direct current, provides wide choice of drive arrangement and of running characteristic, but implies a considerable inventory of high powered machinery and an inevitable loss in effective horse-power. Hydraulic transmissions have in recent years been made to transmit powers in excess of 3000 h.p.[14, 15] and now appear very appropriate for railway traction.

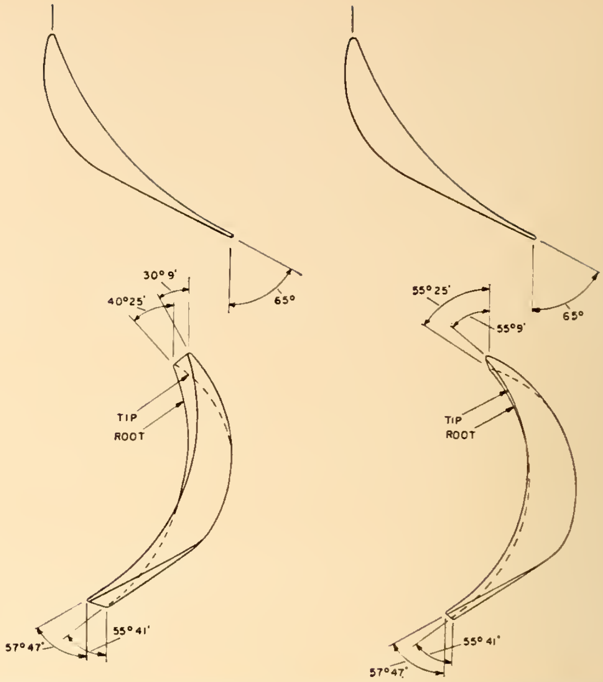
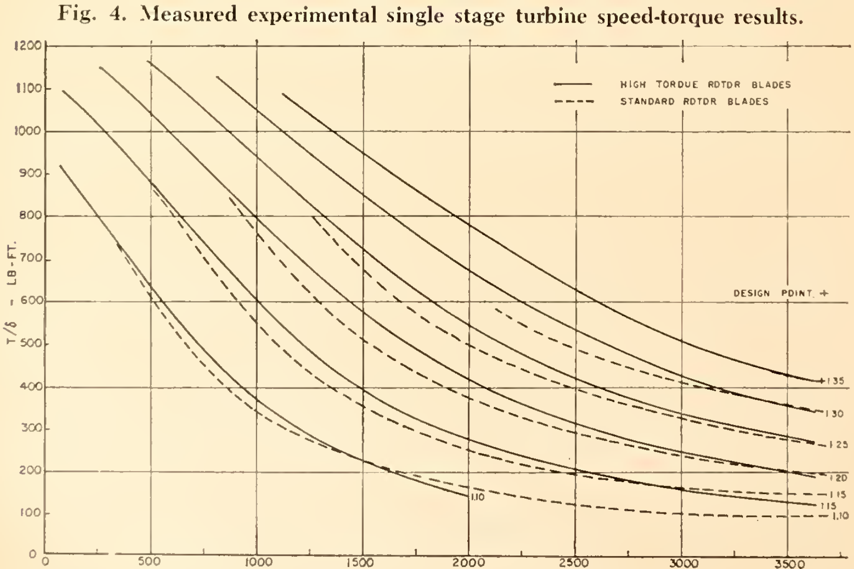


Fig. 3. Left—"Standard" stator blade and "Standard" rotor blade; Right — "Standard" stator blade and "High Torque" rotor blade.

In contrast with the diesel engine, the gas turbine may have a torque at standstill of several times that at the design speed, so that it is analogous to the hydraulic torque converter and very appropriate for traction requirements. It seems to the authors that this feature is one of the main claims of the gas turbine for consideration as an important and economic locomotive powerplant. The distribution of power to a number of running wheels, so elegantly accomplished by electrical transmission, is however a severe problem worthy of very careful attention.

Fig. 4. Measured experimental single stage turbine speed-torque results.



Existing Arrangements

Of the locomotives listed in Table 1, two in France, one in Sweden, and one in Czechoslovakia use a mechanical drive; all employ bevel gears and cardan shafts with universal joints. The final drive of the recent Swedish engine is by means of side coupling rods. In this respect it is similar to the English Electric proposal, the gearing of which has been tested, and the Parsons-North British unit which has also been bench tested. On the other hand, it has been suggested that the most suitable arrangement for a geared transmission is to set the traction turbine shaft transversely—i.e. parallel to the running axles—thus allowing the use of spur or helical gearing.[16] The authors believe that the strength of this arrangement is highly appropriate to conditions in Canada, and gear assemblies of this kind are discussed below.

The main points to be made for

this form of gearing are the facts that it can be made to operate free of end thrust, and it is tolerant of variations in end location and centre distance, especially in comparison with the various forms of right angle drive gearing. Furthermore, it easily accommodates a face width adequate for impact, strength, and wear, and does so without complicating the manufacturing processes.

In the present instance, the proposed scheme of dealing with the various motions of the running axles relative to the main frame is as follows:

(a) Vertical and horizontal motions of axle boxes-coupling rods, and sliding couplings of the "Oldham" type;

(b) Lateral and pivoting motion of trucks — flexible water cooled gas joints.

These arrangements for accommodating the wheel motions involve mounting a traction turbine and its reduction gearing on each truck. Although a variety of centre plate layouts can be contrived, the best suggestion we have so far devised is to use a comparatively large ring surrounding the reduction gear case. In turn this arrangement would probably require forced lubrication to maintain the turning resistance at a satisfactory level, and it implies that trucks be dropped out complete with turbine, gearing, and the banjo surrounding the gear case, without breaking the centre plate joint.

Turbine Speed-Torque Characteristics

Some considerable testing has been directed towards establishing the range of torque available from typical traction arrangements over a range of rotational speed from design down to near standstill conditions.

In the present experiment, a single stage turbine of 20-in. hub diameter and 25-in. blade tip diameter was manufactured for this purpose with two sets of interchangeable rotor blades, each set designed for use with the same nozzles and design point conditions of pressure ratio (1.35:1) and reduced speed (N/θ = 3660 r.p.m.), but with differing design point incidence distributions along the blades. The first set of rotor blades employed conventional incidences on the blades, but for the second set the design point incidences were reduced by some 20° in an effort to improve the gas incidence on the rotos at standstill. It was hoped thereby to increase standstill torque.

The resulting blade sections are shown in Fig. 3. Owing to limitations on the available air supply for driving the turbines, coupled with relatively large losses in the exhaust arrangements in the test installation, it was only possible to cover a range of speed close to the design speed at the full design pressure ratio during the early testing on the conventional blading. Later improvement in technique allowed an extension of speed range at this pressure ratio during the testing of the so-called high torque blading, but the earlier results are still incomplete in this respect. No direct conclusions can yet be made therefore in the efficacy of the high torque blading at standstill conditions. The available results are shown plotted in Figs. 4 and 5 showing the variation of torque and efficiency with reduction of speed from the design point at various stage total pressure ratios for the two types of blading.

The chief points of interest which have been established are:

(a) There is no loss of efficiency or torque at the design point (expansion ratio 1.35:1, N/θ = 3660 r.p.m.) for the "high torque" low incidence blading relative to the conventional blading;

(b) There is a general gain in efficiency and torque down to about 20% design speed for the "high torque" blading, the maximum gain occuring at about 50% design speed;

(c) The range of torque available from standstill to design point speed at the design pressure ratio for the

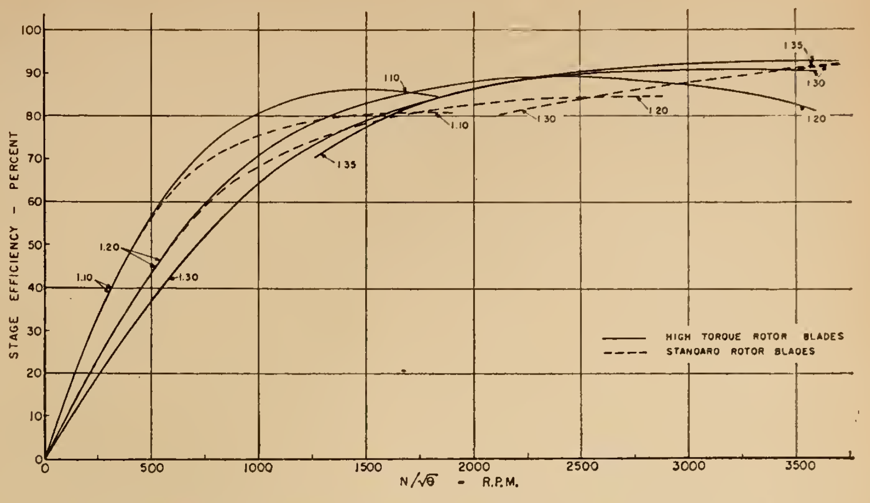
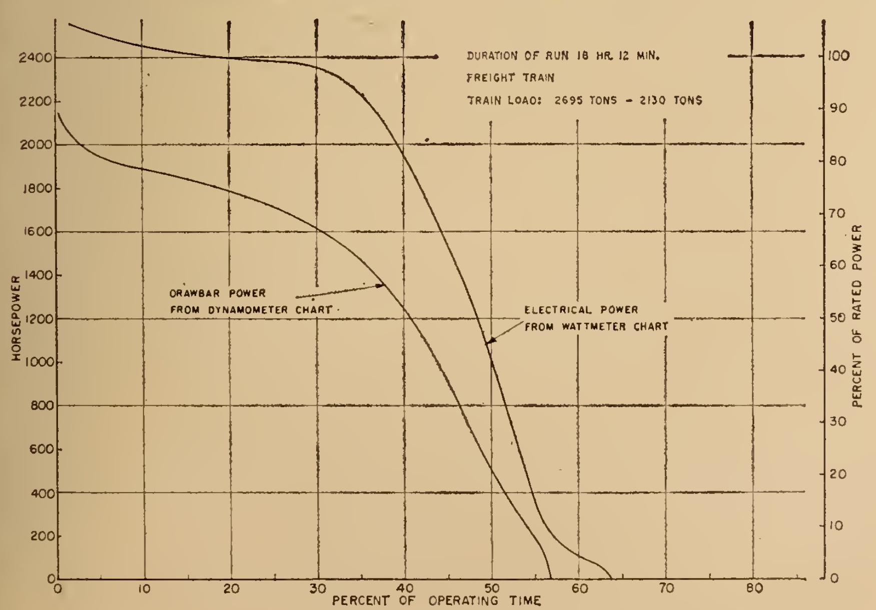


Fig. 5. Measured experimental single stage turbine speed-efficiency results.

Fig. 6. Typical power variation in Canadian locomotive service.



"high torque" blading appears to be at least 3:1.

Proposed Arrangements

Having established the torque-speed characteristics obtainable from a simple traction turbine, it is next necessary to ascertain whether or not a final drive can be devised with the appropriate strength, reliability and running characteristics for the conditions in mind. The requirements have been taken to be:

(a) Transmission of 3200 h.p. through two trucks, with a maximum standstill torque of three times the value at the design point;

(b) Spur gearing only, with coupled axles;

(c) Individual axles or complete trucks to be easily removable;

(d) No gear changing other than simple reversing at rest;

(e) Axle loading 30 tons/axle.

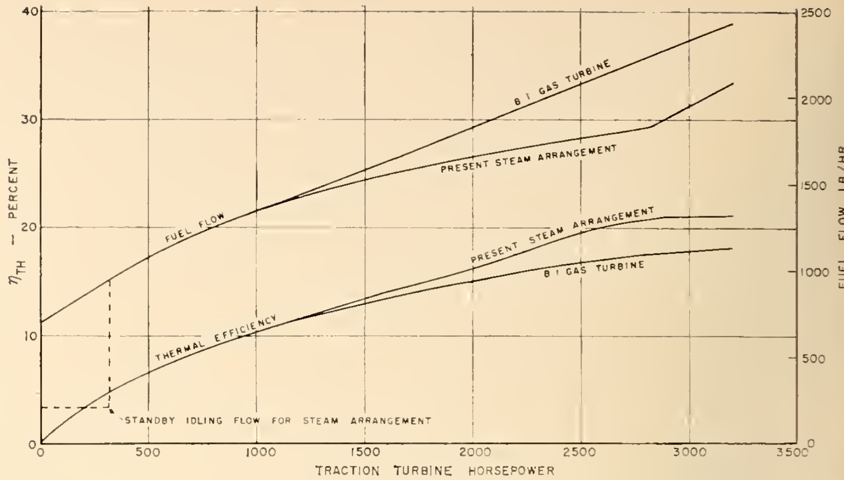


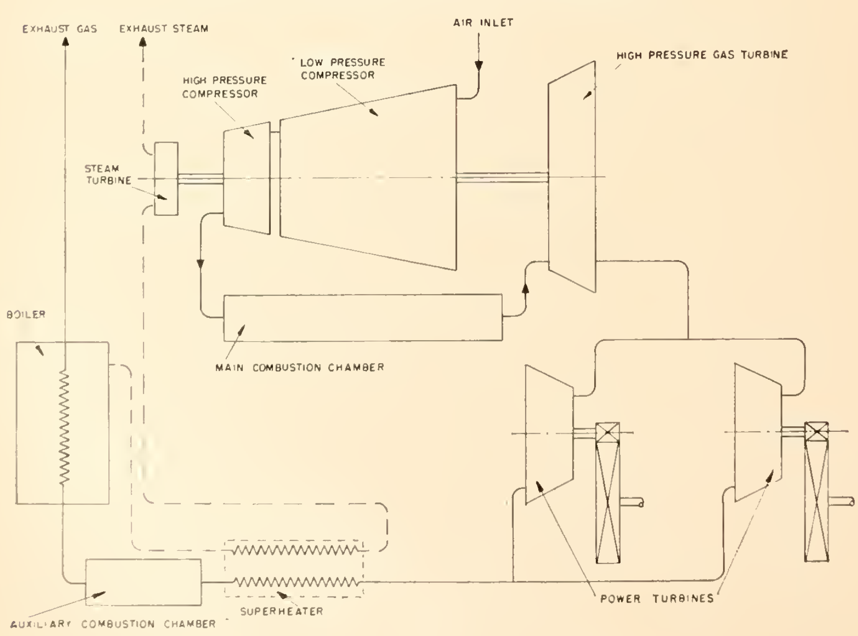
Fig. 7. Approximate part load variation of thermal efficiency.

It appears to be possible to meet these conditions with a reasonably sturdy locomotive. With the above axle loading and a co-efficient of friction of 0.25, the maximum attainable tractive force at the rail amounts to 15000 lb./axle. Traction turbines of 3200 s.h.p. (design point) are capable of 40,000 lb. tractive force at 30 m.p.h. or 30,000 lb. at 40 m.p.h. With a static torque equal to three times that at the design point, the former would have a starting tractive force of 120,000 lb. and the latter 90,000 lb. At 15,000 lb. per axle, gearing for 30 m.p.h. aerodynamic design speed requires a total of eight driven axles, while gearing for 40 m.p.h. aerodynamic design speed requires six driven axles. In both cases the mechanical limit on speed has been taken to be roughly twice that at the design point, i.e. 60 m.p.h. and 80 m.p.h. There are two schemes, the first incorporating coupling of the axles of each truck by means of side rods, and the latter employing spur gearing with sliding couplings. In this connection the experience of the Swiss and the Swedish railways are to be noted. On the latter especially, the coupling rod and jack shaft type of drive is preferred for speeds up to 60 m.p.h.[17]

Load Variation in Actual Service in Canada

A considerable amount of data in the form of dynamometer and wattmeter charts, taken over the entire duration of several typical freight and passenger runs, were analysed to obtain some information on the kind of load variation encountered in service. It was not found possible to define a power-time relationship of general applicability, a wide variation existing between runs, particularly in passenger service. For freight service the results shown in Fig. 6 appeared to be as nearly representative as could be obtained from the data considered. Roughly the locomotive powerplant output was between 90% and 110% of rated load for 35% of the operating time, between zero and 90% for 25% of the operating time, and for 40% of the operating time no tractive effort was required.

Fig. 8. Gas turbine—steam cycle arrangement.



Use of Free Piston Gas Generators

The nearest gas turbine relative of the well established railway diesel engine is the composite system employing a reciprocating free piston generator to supply the hot gases to a power turbine. Attention has already been drawn to several existing locomotives of this type. Electric drive is of course possible with this arrangement and would employ conventional electrical traction gears. Free piston gas generators are also applicable to the form of mechanical transmission proposed and seem to be adaptable to high powers.

In comparison with the purely rotating form of gas turbine, the free piston system attains a considerably higher thermal efficiency. Whether or not it will prove more economical depends both on its ability to burn a cheaper fuel than standard diesel oil and also on the corresponding maintenance costs.

Suitability of Residual Fuel Oils

It appears likely that the frequent

occurrence of very severe boiler tube corrosion reported during the period between 1925 and 1940, and which was sometimes referred to as "catastrophic" corrosion, was in some cases at least due to vanadium attack. The phenomenon was at the time not understood, but it was clear that the attack was not consistent with corrosion rates normally associated with the sulphur or sodium constituents of the fuel. The intensive development of the gas turbine for industrial purposes which began immediately after World War II was slowed down considerably by similar troubles arising from the ash deposition and corrosion accompanying the burning of residual fuels. Bowden and Jefferson in 1949[18] described results obtained in a Parsons 500-h.p. experimental turbine in which compressore surge due to turbine blockage occurred after only 43½ hours' operation on residual fuel. The deposit was confined largely to the first three turbine blade rows and, on analysis, was found to be approximately 40% vanadium oxide. Lloyd and Probert[19] discussed the problem in more detail, and referred to what have since been recognized as the two practical ways to control vanadium troubles. The first is to regulate the combustion in such a way as to produce carbon "cenospheres" which trap a large portion of the ash and aid in scrubbing the remaining deposit from the blades. The second uses additives which convert the vanadium either to a compound which is not active or to one which will raise or lower the melting point and vapour pressure to a point where it is no longer a problem. Amgwerd[20] in 1949 studied the attack of V_2O_5 and of natural ash on a number of alloys over the temperature ranges 650-850°C, and found that the effect of V_2O_5 in promoting oxidation was very marked over the whole temperature range, and that the effect of natural ash containing 66% V_2O_5, 8.7% Na_2O and 12.7% SO_3 was even more vigorous. Later reports by Hughes and Voysey[21] indicate that there was relatively little damage to blading on the Parsons turbine during the fouling process. The corrosion rate is apparently very temperature-sensitive, and the operation of the Parsons plant at 550°C was below the temperature at which attack begins. Analysis of deposit on some of the nickel alloy blades which did show corrosion showed nickel oxide content of approximately 16% as compared with 4 or 5% in the original fuel ash, and a corresponding decrease in blade weight when the oxide and deposit had been removed. Bowden et al.[22] and Draper[23] present curves showing deposition rates and provide a list of suggested mechanisms which might account for the very rapid rates of build-up encountered. At any rate the process is regarded as a complex one in which a number of reactions are involved. They discuss in more detail than did Lloyd and Probert the two methods of reducing deposition by controlled combustion and by additives, and present curves showing the effect of various inorganic additives. Of these, SiO_2, ZnO, MgO and Al_2O_3 are the most effective in the order given and provided stable suspensions can be achieved, are quite promising.

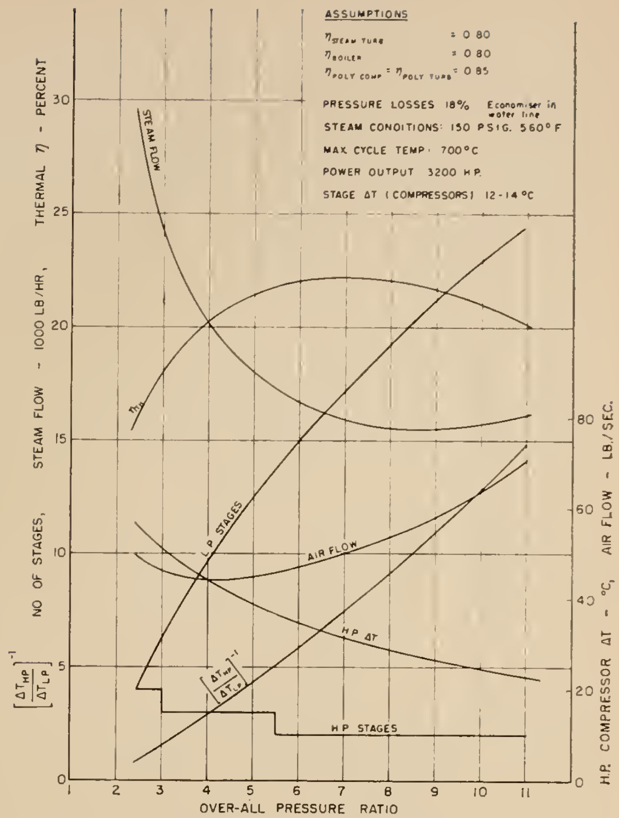


Fig. 9. Gas turbine —steam cycle selection of over-all pressure ratio.

Some deposits[19, 21, 24] do not appear to result in significant corrosion and will in fact wash or break off when the turbine is shut down.

Young et al.[25] describe a method of evaluating the corrosion resistance of blading materials, and Buckland and Sanders[26] describe a process for washing residual fuels where 90% of the sodium and a substantial portion of the calcium is removed. The addition of magnesium oxide to prevent the deposition of vanadium makes the fuel reasonably satisfactory for turbine operation. The authors point out that the addition of lead spoils the effect of the magnesium in inhibiting vanadium deposition, and that when sodium is present in quantities in excess of 10 p.p.m., the ratio wt. of sodium: wt. of vanadium should not exceed 0.3. For inhibiting the vanadium deposits, the ratio wt. of magnesium: wt. of vanadium should be at least 3.

Shortly after extensive oil discoveries in Western Canada, the National Research Council carried out a study of the composition of the various crude oils from Canadian sources and other large oil fields. Table II taken from References 25, 27 and 28 summarizes the results.

The freedom from vanadium and sodium of three types of Canadian crudes suggested that these would be ideal gas turbine fuels. To verify this conclusion a test rig was set up and 12 blades, 4 each of Vitallium, Inconel X and Nimonic 80, were exposed to the combustion products of Leduc bunker C at 700°C for 1000 hours. The results of this experiment are reported in Reference 29 and are essentially as shown in Table III. A conclusion to be drawn from these tests is that the fuel is indeed a satisfactory one, but actual turbine tests are being undertaken as further verification.

General Performance Considerations

The suitability of free power turbines for mechanical transmission (with associated freedom from the cost, losses and complication of elec-

TABLE I
REVIEW OF PRESENT GAS TURBINE LOCOMOTIVES

Manufacturer *Year and Number*	*Operator* *Maximum Speed* *Type of Service*	*Miles Accumulated* *Present State*	*Cycle Arrangement*	*Rated H.P. at Coupling* *Starting Tractive Effort*	*Length* *Weight* *Number of Driven Axles*	*Transmission Type*	*Combustion Chambers* *Fuel*
Metropolitan Vickers 1952 One	British Railways 90 m.p.h. P and F	250,000 Dismantled	Single Shaft Non Recuperative	3,000 60,000 lb.	66′—9″ 130 tons 6	Electrical	6 Metal Cans Light Oil
English Electric Under Test One	— 90 m.p.h. —	—	Recuperator Open Cycle Two Shaft	2,750 —	— 145 tons 4	Mechanical Side Rods	— Light Oil
Parsons and North British Under Construction One	— 75 m.p.h. P and F	—	Two Shaft, Open Cycle Exhaust Heated Traction Turbine	1,860 45,000 lb.	— 117 tons 4	Mechanical Side Rods	One Combustion Chamber Coal
Alan Muntz Proposed One	— 85 m.p.h. —	—	Eight Free Piston plus Two Free Turbines	2,400 35,000 lb.	— 108 tons —	Mechanical Bevel Gear	— Residual and Light Oil
Sigma Renault 1950 One	French National R.R. 77 m.p.h. P and F	200,000 Plus —	One Free Piston plus Traction Turbine	1,000 —	53′—0″ 53 tons —	Mechanical Bevel Gear	— Residual and Light Oil
1958 Two	French National R.R. 79 m.p.h. P and F	— One in Service	Two Free Piston plus Two Traction Turbines	2,000 —	63′—0″ 108 tons —	Mechanical Bevel Gear	— Residual and Light Oil
Götaverken 1955 One	S.S.F. Sweden 56 m.p.h. P and F	120,000 Plus —	Diesel Gasifier and Traction Turbine	1,000 34,100 lb.	— 60 tons 3	Mechanical Side Rod	— Light Oil
1957 One	— — P and F	— Dismantled	Diesel Gasifier and Traction Turbine	500 —	—	Mechanical Side Rod	— Light Oil
Brown Boveri 1941 One	S.F.R. 70 m.p.h. —	180,000 Plus Dismantled	Single Shaft	2,200 28,660 lb.	— 90 tons —	Electrical	— Heavy Oil
1952 One	British Railways 90 m.p.h. P and F	300,000 Plus Presently in Use	Single Shaft	2,500 31,500 lb.	— 116 tons —	Electrical	— Heavy Oil
VI Lenin Works (Skoda) 1958 One	— 77.6 m.p.h. P and F	— Presently in Use	Two Shaft, Open Cycle plus Traction Turbine	— —	— 123 tons 6	Mechanical Bevel Gear	One Combustion Chamber Residual Oil
Kharkov Locomotive Works 1954 One	Russian State R.R. — —	— Presently in Use	One Free Piston plus Traction Turbine	1,000 —	—	Electrical	—
Proposed One	—	—	Single Shaft, Open Cycle plus Recuperator 2 Turbine Units—3,200 H.P. Each	5,250 —	— 137 tons —	Electrical	—
Kolomna Works Proposed One	—	—	Single Shaft, Open Cycle	5,400 —	—	Electrical	—
Proposed One	— 60 m.p.h. —	—	Four Free Piston plus Traction Turbine	6,000 —	— 125 tons —	Electrical	—
Voroshilofgrad Loco Works Proposed One	— 60 m.p.h. —	—	Four Free Piston plus Traction Turbine	6,000 —	— 142.5 tons —	Electrical	—
General Electric 1952 One	U.S. Railways 70 m.p.h. F	250,000 Total —	Single Shaft Open Cycle	4,500 120,000 lb.	— 230 tons —	Electrical	Multiple Chambers Residual Oil
1954 25	Union Pacific 70 m.p.h. F	50 x 10⁶ in 1957 —	Single Shaft Open Cycle	4,500 120,000 lb.	83′—6½″ 230 tons 8	Electrical	Multiple Chambers Residual Oil
1957 15	Union Pacific 66 m.p.h. F	—	Single Shaft Open Cycle	8,500 —	119′—3″ 407 tons 12	Electrical	Multiple Chambers Residual Oil
Westinghouse 1952 One	U.S. Railways 100 m.p.h. F	— Dismantled	Single Shaft Open Cycle	4,000 110,000 lb.	— 230 tons —	Electrical	— Heavy and Residual Oil
L.D.C. Under Test One	— — P and F	Construction Held During 1958	Single Shaft Open Cycle	— 120,000 lb.	— 315 tons —	Electrical	— Coal
Boeing — One	— — F	— In Yard Service	Gas Generator and Traction Turbine	300 21,500 lb.	24′—6″ 29.5 tons	Mechanical Side Rod	— Light Oil
General Motors Proposed One	— — P and F	—	Free Piston Gasifier Traction Turbine Driving Generator	2,000 —	—	Electrical	— Residual Oil
N.R.C. Under Development One	— — F	—	Two Shaft Gas Generator With Steam Turbine Driving H.P. Compressor plus Traction Turbine	3,200 120,000 lb.	72′—0″ 240 tons 6 and 8	Mechanical Spur Gear and Side Rod Models	One Combustion Chamber Residual Oil

tric drive), together with the availability in Canada of cheap residual fuels of low vanadium and sodium content, clearly indicates the possibility of some form of gas turbine powerplant for locomotive use.

Performance Obtainable with the Straight-Through Gas Turbine Cycle

It appears from various analyses that the simple gas turbine is capable at a turbine inlet temperature of 700°C of a reasonable full power efficiency — or at least of a competitive full power fuel cost when burning residual fuel oil. There are also in sight substantial improvements due to increased temperatures in conjunction with blade cooling. In particular, the practice of spraying water or other coolant on the turbine blading has already achieved considerable success in aviation engines[30] and is capable of cooling by several hundred degrees solid blades of conventional sturdy design[31, 32] with correspondingly enhanced full load efficiency.

On the other hand, conventional gas turbine arrangements of reasonable efficiencies at present temperatures imply the use of high pressure ratios requiring large numbers of expensive compressor and turbine blades and/or gas-to-air heat exchangers involving high metal temperatures, high grade materials, and bulk somewhat difficult to house in a locomotive. Further, the straight gas turbine arrangement suffers the severe disadvantage of very high fuel consumption at zero power output (Fig. 7), a condition shown in Fig. 6 to amount to about one-third of the total operating time between terminals. Under these conditions the fuel flow is of the order of 30% of the full load value, comparing very unfavourably with the corresponding diesel value of about 3%.

In addition, the duty of starting motors is not only arduous but must be discharged in a rapid, reliable and highly manoeuvrable way if operating people are to accept the practice of shutting down during yard and station delays, waiting on sidings for meets, and during coasting at zero power. It appears to us, therefore, that the gas turbine is not suitable for general locomotive usage unless the starting arrangements are so efficacious as to avoid any need for fast idling operation. In addition, it is extremely desirable to minimize the variation in the turbine disc and blading temperature in order to avoid repeated thermal shock and fatigue cracking.

The Gas Turbine—Steam Cycle

In an effort to eliminate the undesirable features of the simple gas turbine cycle, a number of arrangements involving more than one basic prime mover—diesel, steam and gas turbine — were considered. Of the schemes examined, the one set out in Fig. 8 and described in the following sections appeared to have certain distinct advantages and was finally adopted for detailed examination.

Cycle Arrangement

Heat exchange is introduced through a waste heat boiler with mild steel tubes and forced circulation and employing steam conditions common to locomotive practice. The energy recovered is returned to the cycle mechanically through a steam turbine driving a high pressure compressor of appropriate dimensions. The normal advantage of heat exchange in reducing the required pressure ratio for maximum efficiency, and hence the number of compressor stages, is thereby reinforced by a large reduction in air flow for a given power output, leading to reduced turbo machinery dimensions at the expense of introducing less critical (and also less efficient) steam turbine blading. Further, the presence of the steam driven compressor affords a method of maintaining a small flow of hot gases through the system to maintain rotor and casing temperatures and boiler pressure under standby conditions. In this way, the main gas generator can be effectively shut down with the energy capacity of the boiler available for a fast restart when required. This feature promises very low standby fuel consumption, and notwithstanding thermo-dynamic inferiority of steam-raising plant in comparison with an exhaust heat exchanger in a gas turbine cycle, and the implied operating problem of using water, the advantages of steam seem to accrue in the following ways:

(a) Recovery of some of the exhaust heat as steam enables the gas turbine cycle to be boosted directly or by means of a steam turbine compressor drive. Either method raises the cycle efficiency and also reduces the sizes and costs of both compressor and gas turbine parts;

(b) The considerable power available in the steam turbine alternative of (a) should accomplish agile starting of extreme reliability. Should a start be prevented by fuel system or ignition trouble, there is no prac-

Table II
Properties of Vanadium content of Canadian No. 6 Fuel

			Venezuela			*Arabian*		*California*			*Canadian*		
Fuel Source and Sample	9268	9925	9280	9930	9939	9327	9936	9927	9934	T.V. 9301	R.W. 9302	Leduc. 9931	R.W. 9933
Sp. Gr.	.982	.969	.999	1.003	.983	.979	1.008	1.004	.989	1.046	1.001	.995	1.007
Viscosity 100 F cs	555	544	651	935	808	303	703	945	432	1080	889	364	1150
Residue, %	9.48	11.6	10.3	10.8	13.4	10.9	14.3	12.8	12.5	10.2	12.2	9.12	14.8
Sulphur, % wt	1.48	1.65	2.36	1.93	2.16	3.0	2.83	0.87	0.67	1.18	1.04	0.73	1.02
Ash, % wt	0.10	0.10	0.05	0.12	0.01	0.03	0.08	0.02	0.03	0.01	0.016	0.03	0.01
Vanadium, p.p.m.	.108	146	84	116	135	126	143	25	14	nil	8.4	2.5	12
Sodium, p.p.m.	150	290	101			6.8	216	5.0	22	1.6	1.7	40.4	8.0

tical limit to the number of subsequent attempts;

(c) Auxiliary power to maintain the lubrication, bearing and disc cooling, and turning gear of an idle gas turbine permits the "hot" parts to be kept hot and relatively free from thermal cycling and shock;

(d) A supply of steam is one of the simplest, cheapest, and most convenient ways of heating and atomizing bunker fuel oil and for train heating, where required;

(e) Recuperation of exhaust heat in the form of steam rather than combustion gas permits the heat exchange system to be constructed of mild steel rather than the more expensive stainless alloys;

(f) Partial duplication of auxiliary power supply driven by steam permits reduction of the necessary diesel or semi-diesel alternator set to a size which can be started by hand.

Fig. 9 illustrates the variation of efficiency and required air flow with over-all pressure ratio for the steam cycle considered here, assuming the high pressure compressor absorbs the whole of the available waste heat at the design point. Also plotted are the number of compressor stages required, the design point steam flow (water consumption), and the ratio of the high pressure compressor temperature rise to the low pressure compressor temperature rise. The latter factor has a bearing on the capability of the system for quick restarting from the standby condition and has a practically useful minimum limit. Consideration of the various factors illustrated by curves of this type led to the selection of an over-all pressure ratio of 4.5:1 with a steam driven compressor temperature rise of 35°C, the latter value being somewhat less than the maximum available to allow a margin for auxiliary steam requirements (including train heating) and reduced exhaust temperatures at low ambient temperatures. The maximum cycle temperature was set at 700°C.

In this arrangement the main operating procedures are envisaged rather as follows:

Stone cold to stand-by:

(a) Start auxiliary (semi)-diesel engine;

(b) Fill boiler with water or, if practicable, with hot water and steam from shop supply;

(c) Start auxiliary lubricating pump and main compressor turning gear;

(d) Light main and auxiliary combustion pilots;

(e) When steam is available, start steam turbine to turn high pressure compressor slowly as a forced draught fan;

(f) Turn on steam heat to bunker fuel, atomizing steam and, in cold weather, heat to water tank;

(g) Start steam driven alternator to protect superheater and to supply fuel pump, air pump, and main lights;

(h) Gas turbine heats nearly to running temperature, gas generator being turned over at 50 r.p.m.

Table III
Gas turbine blade corrosion results for Bunker C combustion tests. (Leduc Crude)

		Vitallium	*Inconel X*	*Nimonic 80*
Mean Rate of Build-Up	mg./cm.²/1000 hr.	3.25	—1.78	—5.33
Mean Rate of Metal Wastage	mg./cm.²/1000 hr.	6.72	8.20	12.68
Mean Rate of Metal Wastage	in./1000 hr.	0.00031	0.00039	0.00061

Stand-by—Normal Running

As the main throttle is opened, the following series of automatic control adjustments is proposed:

(a) Steam turbine throttle opens and main combustion chamber temperature rises, with fuel flow limited by a rate of temperature rise control;

(b) As the main gas generator set reaches the required speed, the high pressure compressor speed adjusts automatically to use the steam produced, and the auxiliary burner adjusts to maintain constant steam pressure;

(c) Should the wheels slip, quick closing of the throttle is arranged to open a discharge on the gas generator exhaust, with automatic closing.

It is evident that an advantageous execution on the above lines would ameliorate very much the basic disadvantages of gas turbine machinery, but with the operating disadvantage of requiring water.

The thermal efficiency and air flow requirements of the gas turbine — steam cycle, and a straight gas turbine cycle have been compared for the same maximum temperature with various assumed system pressure losses and with no heat exchange.

There is marked improvement in the efficiency and reduced air flow of the steam assisted cycle-even at relatively moderate pressure ratios—over the "straight" system at an optimum pressure ratio of about 8:1. The selected design point values for the steam assisted cycle led to a 12-stage low pressure compressor, 3-stage high pressure compressor, 2-stage gas turbine driving the low pressure compressor followed by two 2-stage traction turbines in parallel. With careful attention to pressure losses throughout the system, an output of 3200 h.p. is expected from an air flow of 43.75 lb. sec. at a thermal efficiency of 21% (s.f.c. = 0.65 lb./h.p. hr.)

A study of a two-shaft gas turbine cycle of 8:1 pressure ratio and the same maximum temperature of 700° C indicated an air flow of 65 lb./sec. for the same output at an efficiency of about 18%. A total of 22 compressor stages and about 3000 compressor blades were indicated, compared with 15 compressor stages and 1900 compressor blades for the arrangement involving steam.

Approximate Part-Load Performance

In order to maintain the high pressure compressor at a speed appropriate to aerodynamic matching of the turbo machinery, it is necessary to augment the exhaust heat by combustion in an auxiliary burner before the boiler at ratings less than about 90% full load, depending on the auxiliary steam requirements. The required matching speed of the high pressure compressor is almost constant at the design point value down to about 10% full load. Some limited testing has been carried out on the existing boiler-steam turbine-high pressure compressor combination. A simulated standby idling air flow of 5 lb. sec. at 400°C (fuel flow about 10% full load) was applied to a completely cold boiler and the boiler pressure raised to about 100 p.s.i.g. The response of the high pressure compressor system at atmospheric intake to opening of the steam throttle was obtained with the rate of firing held constant at a level corresponding to idling fuel flow. The compressor system was able to accelerate to and maintain its governed design speed without increase of the heat supplied to the boiler. The behaviour of the actual locomotive arrangement with the low pressure compressor in position and direct connection on the gas side with the boiler represents of course a somewhat extreme extrapolation from these tests: examination of the capability of the steam turbine to start the whole system, the required initial boiler conditions for effective starting, and the required compressor management during starting, is now being made. Results from this work will establish the minimum heat supply necessary during stand-by periods to enable a rapid start to be made. On applying the results of Section 4, Fig. 6, to the fuel flow values of Fig. 7, one would expect the mixed cycle powerplant of 3200 h.p. rated output to consume 1200 lb. of residual oil per hour of operating time. For a diesel-electric powerplant of the same capacity the comparable consumption would be about 800 lb. (of diesel oil). The expected fuel consumption per operating hour of the straight gas turbine with mechanical drive is 1540 lb./hr. These figures are approximate and are summarized in Table IV which also includes an estimate for a free piston unit with mechanical drive. The relative costs would naturally depend on the unit prices of the fuels in question. Although the mixed cycle powerplant appears likely to show to advantage when burning bunker fuel at half the unit price of diesel fuel, it needs to be emphasized that fuel cost alone is only one criterion by which to make a sound comparison.

Table IV
Approximate fuel flows per operating hour
3200 H.P. to Wheels

Arrangement	*Idling fuel flow per hour idling*	*Fuel flow per operating hour*	*Fuel cost per lb.*	*Fuel cost per operating hour*
Mixed Cycle—Mechanical	210	1200	1c	$12.00
Straight Cycle—Mechanical	700	1540	1c	$15.40
Free Piston—Mechanical	240	700	2c	$14.00
Diesel—Electric	50	800	2c	$16.00

Variation of performance with Ambient Temperature

In common with the straight gas turbine, although to a reduced degree, the mixed cycle arrangement exhibits pronounced variation of output with ambient temperature. An increase of about 30% (i.e. 1000 h.p.) over the rated 3200 h.p. is expected for ambient temperatures in the neighbourhood of 0°F, at maximum gas generator r.p.m.

Traction Turbine Characteristics, and Available Tractive Effort

Some considerable testing has been directed towards establishing the range of torque available from typical single stage traction turbines over a range of rotational speed from design down to near standstill conditions. The curves of Fig. 4 show measured results for two arrangements tested. These results have been used to estimate the torque-speed relationship for the two-stage power turbines of the actual locomotive powerplant. With a conventional loading of 60,000 lb./axle and an assumed factor of adhesion of 0.25, an engine of 3200 h.p. requires eight drive axles if geared for a maximum service speed of 60 m.p.h. and six axles if geared for 80 m.p.h. For the powerplant considered here the power turbine design speed is 5200 r.p.m. and the wheel diameter is 48 in. At low ambient temperatures the maximum available stand-still torque is greater than that required to slip the wheels (at 60,000 lb./axle and 0.25 factor of adhesion), and partial throttle is required from standstill with progressive opening up to full throttle as speed is picked up, for maximum train acceleration. In practice the factor of adhesion with coupled axles might exceed the above assumed figures of 0.25 [14, 17].

Weight Changes Due to Fuel and Water Consumption

Apart from the problems of supply, the use of water in a locomotive implies a change in the weight on the wheels. In the present instance it is suggested that 3100 gal. of water (and all the fuel) be carried on the engine chassis and further water in a tank car or tender. The corresponding variation in weight on the driving wheels would entail greater risk of slipping with tanks empty, but the additional adhesion required seems to be within the margin ascribed to coupled wheels [11,13].

Construction of the Experimental Plant

In setting out the mechanical design of this experimental gas turbine, one object was to make a result reasonably ready for industrial exploitation and development and also appropriate for general railway application. Considerable effort has been made to incorporate various features such as ease of manufacture, simplicity and accessibility for maintenance, sturdiness, freedom from close tolerances and critical materials, and the need for special manufacturing facilities and services.

The compressor casings are split on the centre-line to allow convenient assembly and easy inspection of rotor and stator blades, the latter being easily removable in sections. With one exception the bearings are accessible directly by removing caps, and all but one are identical. The turbine casings are complete rings with the object of avoiding excessive distortion.

Built-up rotor construction with dovetails to hold the rotor blades is employed in the low pressure compressor, which with its turbine is carried on a single shaft in two large journal bearings. The high pressure compressor at present has three bearings.

The compressor blades are made of stainless steel of heavy section in an effort to ensure freedom from vibration and erosion problems. All blades in each compressor are the same and are cropped from stage to stage to provide the proper flow areas.

Mounting the high pressure turbine on the low pressure compressor shaft has the disadvantage of limiting rather sharply the space available for the turbine outlet diffuser. The arrangement shown on both the high pressure compressor outlet and the high pressure turbine outlet is, however, aerodynamically quite efficient, with a pressure recovery equal to about 90% of the gas exit velocity head. At this stage, treatment of the flow is no longer critical and bends may be introduced without serious loss. Duct velocities are kept low to minimize distribution losses, and turning vanes are employed where it appeared profitable to do so. The turbine rotor material is G18 B, the stator blades are Vitallium, and the rotor blades are Inconel X. While the cycle temperature employed does not demand materials of this standard, the fact that they are used allows one the possibility of increasing the maximum power without creating undue stress problems and at the same time ensuring a long component life.

The turbine blading in common with the compressor blading employs constant section profiles which can be generated by straight lines, thereby allowing maximum scope in the method of machining the profile.

Combustion takes place in a single metal chamber, with air cooled flame tube and liner, employing steam atomization. Ignition is obtained by means of a pilot torch burning diesel oil which can be lit by an electric spark or with a match. The torch burns only a fraction of a gallon per hour and remains lighted so long as the system is alive. The main burner, injecting bunker C fuel, can be shut down and relighted without difficulty.

Precise figures for combustion efficiency have not so far been obtained; but, on the basis of mass flow and temperature measurements, the combustion efficiency is estimated to be in the neighbourhood of 98%.

The steam boiler being used for the experiments is of LaMont forced circulation type with mild steel tubing, and incorporates an auxiliary combustion chamber which will be dispensed with if operation without it proves feasible.

Conclusions

The requirements of railway traction are generally met in a very capable way by the diesel engine which, when employing electric or hydraulic transmission, makes a very economical and flexible locomotive.

If the gas turbine is to compete with it on a comercially sound basis to any appreciable extent, the authors feel that all of its potential advantages must be exploited. These appear to be substantial and generally as follows:

1. The torque speed characteristic of the turbine makes it practicable to use simple mechanical coupling to the wheels with a potential gain in starting tractive effort due to improved adhesion, reduced capital cost, and reduced maintenance costs;

2. The inherent ability of the gas turbine to use low grade fuels is outstanding, and, together with the fact that the cycle is peculiarly adaptable to waste heat recovery, allows the possibility of substantial savings in fuel costs;

3. To achieve a saving in fuel costs it is necessary to provide the locomotive with an idling fuel consumption cost comparable to that of the diesel engine, and so ensure rapid reliable starts when required if operators are to take advantage of this feature.

The proposed design is intended to take some advantage of these possibilities. Further assessment will have to await additional tests and experience.

Acknowledgement

A great deal of the effort which has gone into this project came from other staff members of the National Research Council whose names do not appear. The authors wish specifically to acknowledge and express their appreciation for the co-operation and assistance of the staff in the Mechanical Engineering Divisional Shop where the turbine was to a very large extent manufactured; and to the design, engineering and shop staff of the Gas Dynamics Section for their co-operation and enthusiastic effort in bringing the project to its present state. They wish also to express appreciation to staff members of the two Canadian railways who have been most cooperative in supplying information and helpful in their suggestions, and to members of various industrial organizations for their general interest in the project and for their suggestions and comments on pertinent aspects of the proposed arrangement.

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LITTORAL DRIFT IN LAKE ONTARIO HARBOURS

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THE PROBLEMS created by littoral drift—which may be loosely defined as the transport by waves, tides and coastal currents of littoral or beach material along the shores of large bodies of water—are present all over the world. The erosion of valuable land in some places and damage to channels and harbours by siltation in others occurs at greater or lesser rates wherever there are supplies of beach material and water with sufficient energy content to move them.

On the north shore of Lake Ontario the erosion at Scarborough Bluffs is well known and erosion at less spectacular rates does occur along much of the coast. Some idea of the magnitude of the siltation may be gained from the typical annual dredging figures given below.

Cobourg Harbour	31,700 cu. yd.
Port Hope Harbour	25,000 cu. yd.
Bowmanville (pleasure craft only)	1,650 cu. yd.
Oshawa	15,000 cu. yd.
Port Whitby	4,865 cu. yd.
Toronto Eastern Gap	36,000 cu. yd.

With the exception of Hamilton and Toronto the harbours on the north shore of Lake Ontario will not be able to accommodate ships of the Seaway draft. Since these smaller harbours hope to share in the increased trade which the Seaway is expected to bring, it is apparent that information will be required regarding the way in which any proposed changes would affect the annual maintenance cost and the beaches in the vicinity.

Fig. 1.

In some countries there is a particular agency or department charged with the study of these problems—in the United States it is the Beach Erosion Board. In Canada the Department of Public Works, which is responsible for the maintenance of most harbours, has long been aware of the problems but has not been able to devote much time to detailed studies. Toward the end of 1957 the Department asked the National Research Council for assistance, and in early 1958 the National Research Council Associate Committee on Waves and Littoral Drift was set up. The Committee has initiated a twofold program of basic investigation and field measurements using the facilities of the Department of Public Works, the National Research Council and Queen's University.

This paper deals with the question of littoral drift and the Committee's program under the following headings:

Source of Littoral Material.
Rate of Supply.
Mechanism of Transport.
Theory of Waves.
Wave effect.
Remedial Measures.
Program of Investigation.

Source of Littoral Material

Lake Ontario (Fig. 1) which has an area of over 7,000 sq. miles and a mean water level in the region of

246.0 ft. above sea-level occupies a limestone and shale basin formed in an early geological period which has subsequently been scraped out and enlarged by glacial action.

Outcrops of bedrock limestone occur frequently between Kingston and Presqu'ile, infrequently between there and Cobourg and not at all between Cobourg and Toronto. The overburden on this north shore consists of stratified silt, sand, gravel and boulder clay varying in depth from a few feet to many hundreds of feet. The contours are such that there are swamps at the shore in some areas and bluffs rising high above lake level in others, the Scarborough Bluffs for instance, reaching a height of nearly 200 ft.

Being of such a friable nature this unconsolidated material offers little resistance to erosion of any type and once eroded is the prime source of littoral material. A typical grading curve for soil taken from the bluffs to the west of Oshawa is shown in Figure 2.

The agencies involved in shore erosion are wind, surface drainage and wave-action, the latter being by far the most important. Having been deposited by erosion at the base of the bluffs and on the beaches near them, this material is then subjected to littoral processes. Since the material along the bluffs is very similar at all locations it is virtually impossible by mechanical analysis alone to state the exact geographical location of the source of any littoral material. However, the net direction of travel over long periods may be obtained from aerial photographs or surveys. Figs. 3 and 4 show the harbours of Cobourg and Port Whitby. At Cobourg the littoral drift is west to east as evidenced by accretion on the west side of the harbour breakwaters and depletion on the east. At Port Whitby the net littoral drift is from east to west as evidenced by depletion to the west of the harbour. Somewhere between Oshawa and Port Whitby there is a null point.

Littoral drift may be toward the east one day and toward the west another. The direction depends upon the direction of the wave motion while the rate of drift is some function of wave energy which in turn is related to the fetch and to the wind velocity. Thus the net drift at any point will depend upon the direction, duration and velocity of the winds and upon the fetch or distance which the waves travel. It seems that the prevailing south-west wind in the Toronto-Scarborough area does not cause as much easterly littoral drift as the less frequent south-east wind which has a longer fetch. Farther east, where the relative fetch distances are reversed, the direction on the net drift is also reversed.

It is sometimes suggested that currents caused by the Niagara River, which enters Lake Ontario from the south, caused the littoral drift to the west in the Scarborough-Toronto area. The authors have examined this theory and do not believe that it has any basis in fact.

A typical profile of the shore on the west side of Cobourg Harbour is shown in Fig. 5 along with grading curves of the beach material in Fig. 6.

It is interesting to note the excellent grading of the material as well as the change in mean particle size with distance from shore—the finer material being found in deeper water. Similarly graded sands found off the southern shore of Lake Ontario at one time were a source of material for construction purposes. Severe erosion on these shores was rightly or wrongly associated in the minds of many with the removal of this material. As a result—the authors understand—the State of New York now forbids the dredging of such material within its State limits.

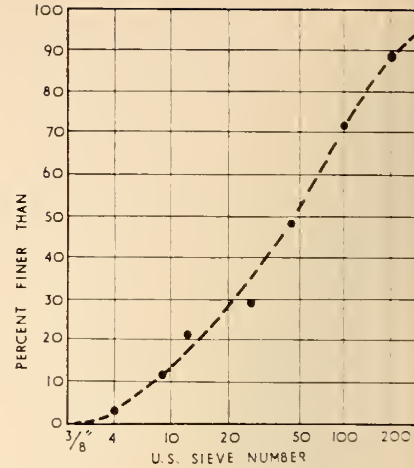
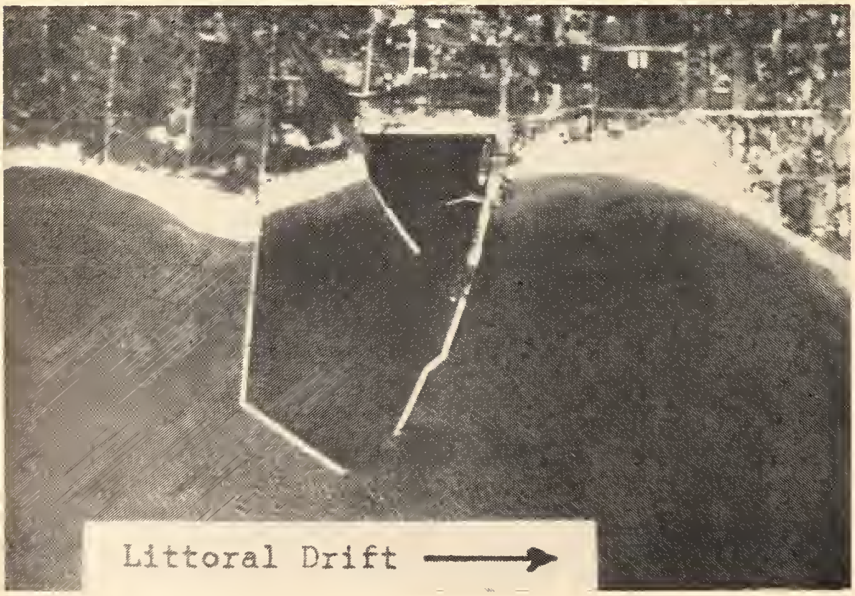


Fig. 2.

Fig. 3.



The Rate of Supply of Littoral Material

Since littoral material must be supplied from the shore, the rate of shore erosion is a measure of the rate of supply. Because the process of erosion is slow and the rate irregular, measurement can be made only by comparing surveys or aerial photographs taken over fairly lengthy intervals. In the case of the Scarborough Bluffs to the east of Toronto the erosion is reported to be of the order of 1 to 2 ft. per year. Since these bluffs are roughly 200 ft. high the average annual contribution must be about 300 cu. ft. of material per ft. of shore line. Assuming that a substantial proportion of the fines are carried out into deep water and lost, it is still evident that a mile of shore could supply the annual dredge at Toronto Harbours eastern gap, namely 36,000 cu. yd.

A sloping beach protects the shore behind it by dissipating part of the energy of the wave as it comes in. For this reason erosion proceeds faster during years in which high water partially submerges the beaches and allows a larger proportion of the wave energy content to be applied to the shores. If the new dams on the St. Lawrence make it possible to reduce the fluctuations in the level of lake Ontario, the rate of erosion in the future should be more uniform than it has been in the past.

Figs. 7 and 8 are reproductions of aerial photographs taken at Cobourg Harbour with an interval of 23 years between them. The lake level in Fig. 7, April 1931, was around 245.0, whereas in the summer of 1954, the date of Fig. 8, the level was around 247.5. The scale of these particular photographs is such that it is virtually impossible to derive quantitative figures for the rate of erosion. However, there is definite evidence of accretion to the west of the western breakwater.

The Mechanism of Transport of Littoral Material

The transport of sediment or littoral material may take place under the action of:

(a) tidal currents;
(b) river and estuary currents;
(c) wind driven surface currents;
(d) waves and the currents and movements generated by them.

As far as Lake Ontario is concerned tidal currents are negligible, and the Niagara River with its mean inflow of around 250,000 cfs. would appear to be quite incapable of causing any littoral transport on the north shore. (There is some evidence of density currents due to temperature gradients but—in the authors' opinion—none on the north shore, due to the Niagara River). Wind driven surface currents do not cause sufficient movement below the surface to give rise to appreciable transport of any sediment except perhaps very fine clay.

The main mechanism responsible for the movement of littoral material in Lake Ontario is wave action and its associated long-shore currents. Waves coming in at an angle to the coast line usually set up long-shore currents at the breaker zone, and such currents play a vital role in the transport of littoral material. Even the casual observer may note that waves coming in at an angle to a gravel beach carry pieces up the beach in an oblique direction and then roll them down again in a direction at right angles to the water line. Following such a zigzag path the coarse pieces are thus transported along the beach. It is easy to imagine that farther out the sand and finer particles stirred into temporary suspension by the waves are being moved in the same general direction by the long-shore current. However, despite the importance of the problem and the work which is being carried out on it in various parts of the world, the fundamental mechanism of this transport is still imperfectly understood.

Fig. 4.

As waves are the prime movers of littoral material it may be well to examine briefly the basic mathematical theories of wave motion which have been proposed.

The Theory of Waves

Waves in general may be regarded as being either of the oscillatory or translatory type. Oscillatory waves which originate in relatively deep water often acquire many of the characteristics of translatory waves as they move into shallowing water.

The variables involved in the description of water waves are defined below:

L = the wave length: the horizontal distance between similar points on two successive wave-crests measured perpendicular to the crest;

T = the wave period: the interval of time between the passage of two successive wave crests at a fixed point;

c = the speed or velocity of the wave: the speed with which an individual wave advances;

d = the depth of water measured in a vertical direction from the still water surface to the bottom;

H = the wave height: the vertical distance from the crest of the wave to the bottom of the succeeding trough;

d/L = the relative depth;

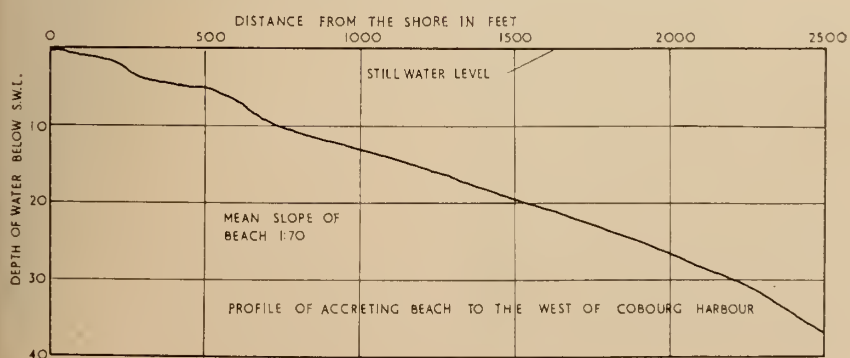
H/L = the wave steepness.

Oscillatory Waves

There are various theories regarding the form of the surface of oscillatory waves. The surface may be assumed to be sinusoidal (Airy), trochoidal (Gerstner) or sinusoidal with modifications (Stokes) which makes the wave crest more pointed and the troughs longer and flatter.

Irrespective of the wave form the velocity of the wave is given fairly

Fig. 5. Profile of Accreting beach to the west of Cobourg Harbour.



accurately by the expression:

$$c^2 = \frac{gL}{2\pi}\tanh\left(\frac{2\pi d}{L}\right)$$

since $C = \frac{L}{T}$ this can be written in the form

$$L = \frac{gT^2}{2\pi}\tanh\left(\frac{2\pi d}{L}\right)$$

and is plotted in Fig. 9 as such for various periods T ranging from 1 sec. to 10 sec.

It may be seen that in deep water, usually defined as depth exceeding one half the wave length $(d/L > 0.5)$, $\tanh (2\pi d)/L$ is sensibly equal to unity and hence c tends to $\sqrt{(gL/2\pi)}$ In shallow water, usually defined as depth less than 0.05 times the wave length $(d/L < 0.05)$, $\tanh 2\pi d/L$ tends to $2\pi d/L$ and hence c tends to $\sqrt{gd}$

It will be noted that the relationship for c, T and L contains no reference to wave-height H. However, using the Stokian wave theory the relationship for velocity can be shown to have the form

$$c^2 = \frac{gL}{2\pi}\left(1 + \pi^2\left(\frac{H}{L}\right)^2\right)$$

for the deep water case. Since in general the steepness H/L of the wave is small this additive term has little effect and so the approximate expression

$$c^2 = \frac{gL}{2\pi}$$

is usually sufficient for all practical purposes.

In a wave the particles of fluid are continually in motion. The particles of fluid in an oscillatory wave system describe closed elliptical orbits, the major and minor diameters of the ellipses depending on the relative depth in which the wave is travelling and the position of a particle relative to the still water level. If y is the depth of a particle below the still water level its elliptical path is given by:

semi-major horizontal diameter =

$$= \frac{H}{2} \cdot \frac{\cosh \frac{2\pi}{L}(d - y)}{\sinh \frac{2\pi d}{L}}$$

semi-minor vertical diameter =

$$= \frac{H}{2} \cdot \frac{\sinh \frac{2\pi}{L}(d - y)}{\sinh \frac{2\pi d}{L}}$$

For deep water that is $d/L > 0.5$, these reduce to circles of radius given by the relationship

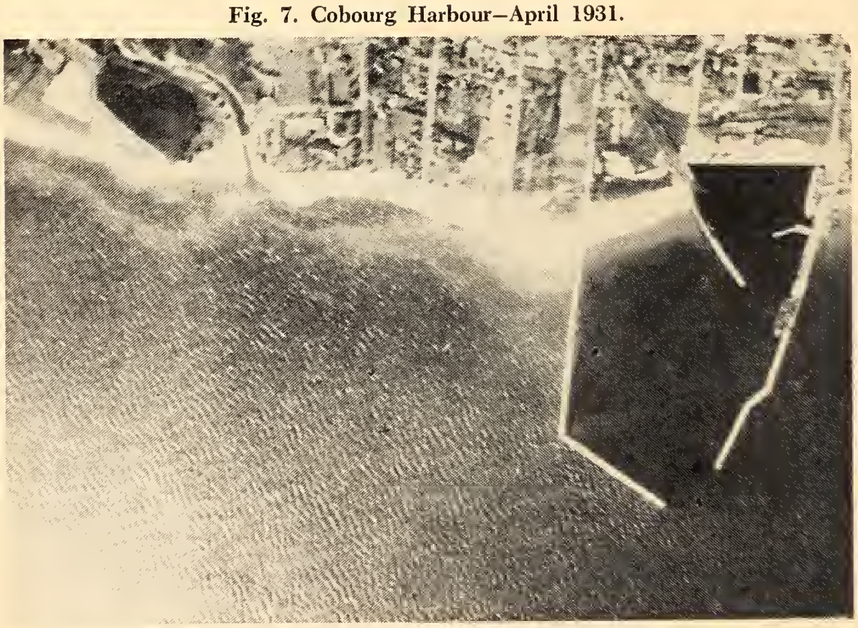
$$\text{radius at any depth } y = \frac{H}{2} \cdot e^{-\frac{2\pi y}{L}}$$

On the surface, $y = 0$, the orbital radius is $H/2$. At a relative depth, y/L, of 0.5 the radius of orbit is sensibly zero. Thus, in so-called deep water, the passage of a wave is unnoticed at depths greater than half a wave length.

For shallow water, that is $d/L < 0.05$, the elliptical orbits do not degenerate into circles nor die away with depth. At $y = d$, that is on the bottom, the particle oscillites backwards and forward in a straight line with a whole amplitude of

$$\frac{H}{\sinh (2\pi d/L)}$$

Fig. 7. Cobourg Harbour—April 1931.



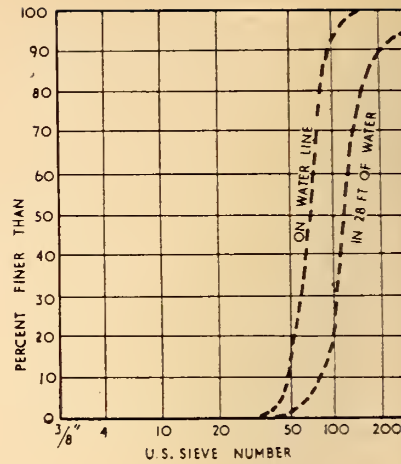


Fig. 6.

whilst on the surface the particle has a whole vertical movement of H and a whole horizontal movement of

$$\frac{H}{\coth (2\pi d/L)}$$

Thus oscillatory waves in shallow water and in the transition between deep and shallow are capable of carrying material into suspension and into oscillatory but not translatory motion.

Solitary Waves

The theory for the solitary wave supposes the existence of only one wave whose two limbs on either side of the elevated crest decrease rapidly in elevation away from the crest.

If y is the elevation of the waveform from the undisturbed level an infinite distance on either side of the crest the equation for the surface is given by

$$y = H \operatorname{sech}^2 \frac{x}{2b}$$

where H is the height of the crest above still-water level,

x is the horizontal distance from the crest on either side,

b is a function of the depth d and the wave height H given by various expressions of which the Boussinesq solution is quite adequate, namely,

$$b = \sqrt{\frac{d^3}{3H}}$$

The solitary wave in theory stretches its limbs to infinity on each side, but in practice it is found that to all intents and purposes the volume of water in the wave is contained in a length equal to about four times the depth on each side of the crest. Hence there is the possibility that a series of solitary waves in shallow water, the proper distance apart, could appear to be a train of waves but behave as solitary waves. Fig. 10 shows the profile of a typical solitary wave.

The motion of the water particles in a solitary wave is markedly different from the motion in an oscillatory wave. The solitary wave gives a horizontal movement which is sensibly constant at all depths and in this respect is similar to the oscillatory wave in shallow water. However, the solitary wave motion is not an oscillation but a forward movement or translation. The forward displacement as a solitary wave crest passes through the undisturbed water is given (approximately) by $4\sqrt{dH/3}$, the forward path being quasi-parabolic. This is explicable if one thinks of the particles moving forward with the crest and remaining displaced until the next crest passes through, since in a solitary wave there is no real trough to impart a backward motion.

Wave Energy

The energy contained in an oscillatory wave in deep water consists of potential and kinetic energy. It may be shown that the total energy contained in such a wave is given by

$$1/8 \cdot w \cdot L \cdot H^2$$

ft. lb. per ft. of crest length.

The total energy contained in a

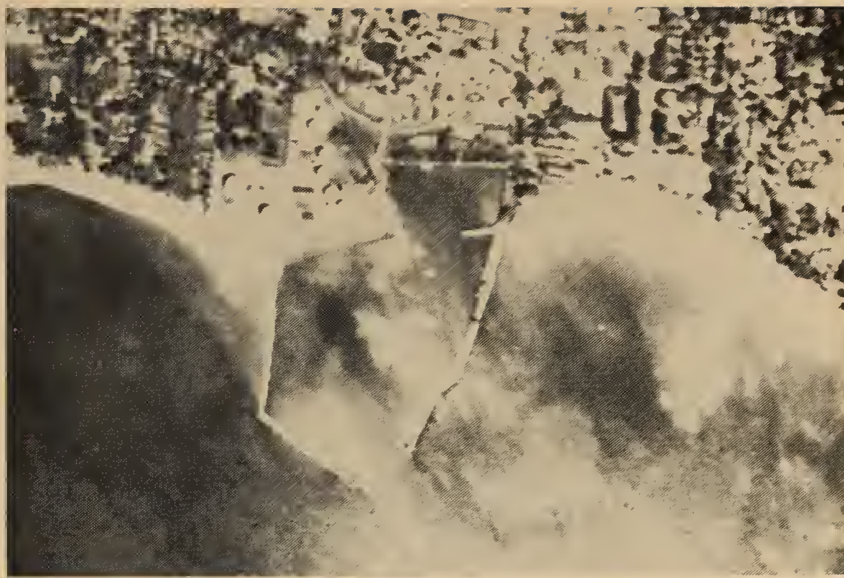


Fig. 8. Cobourg Harbour—summer 1954.

solitary wave also consists of potential and kinetic energy and may be shown to have a value given by

$$8/(3\sqrt{3}) \cdot w \cdot \sqrt{H^3 d^3}$$

ft. lb. per ft. of crest length.

As stated above, most of the volume of the solitary wave is located near the crest; the total energy content is even more concentrated, 98% of it being located within a distance equal to $2d$ on either side of the crest.

With the theory as background, the effect of waves upon the shore will now be examined.

Wave Effects

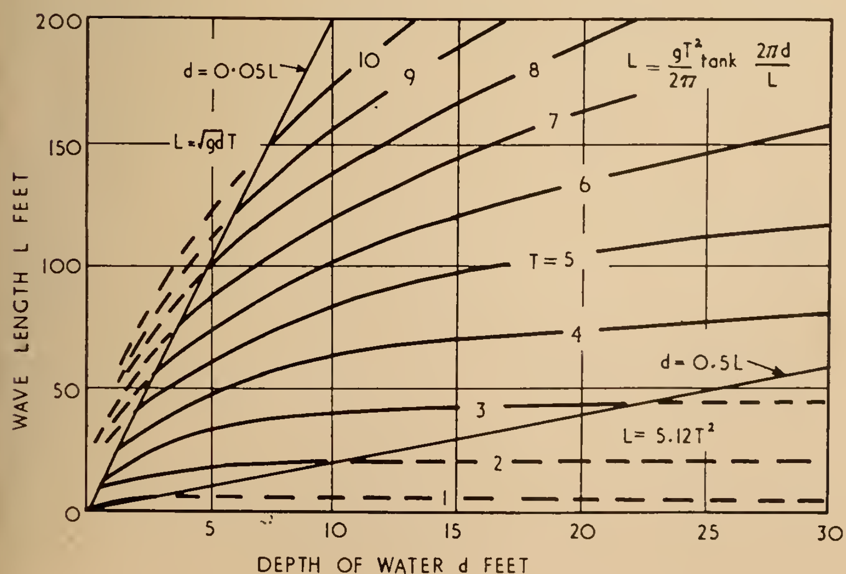
Oscillatory waves are normally generated in deep water far from shore by the action of the wind. The wave motion so generated moves shorewards, usually picking up more energy from the wind as it goes.

To an observer these waves in deep water appear to be rolling in towards the shore in a manner which suggests that any floating or suspended material would be carried with them. In fact the forward motion is far more apparent than real since, as has been stated, the water particles move in nearly closed circular orbits and have little or no net movement. As the waves move into shallowing water when the shore is approached they are effected somewhat by the resistance of the bottom and the circular orbits tend to be flattened into ellipses.

A storm wave of 4 sec. period in deep water on Lake Ontario, for example, would have a wave-length of about 80 ft. as shown in Fig. 9. Such a wave would not be felt on the bottom until the depth of water was less than 40 ft. As it continued shoreward in ever shallowing water it would be slowed down, with an accompanying decrease in wave length. Since the energy of the wave in deep water can be modified only by loss due to bed friction as it moves shorewards, the shortening of the wave length in shallowing water is accompanied by a steepening of the wave. At a depth of 16 ft. its length would be reduced to about 72 ft. and its height might be slightly increased (if there were no loss of energy the height would be increased by about $\sqrt{80/72}$, (or 5 %).

The total energy possessed by a wave in deep water has been stated

Fig. 9.



to be

$$1/8 \cdot w \cdot L \cdot H^2$$

ft. lb. per ft. of crest length. By mathematical analysis it may be shown that, to a first approximation, the energy transmitted forward from deep water towards the shore is one half of the total, namely

$$1/16 \cdot w \cdot L \cdot H^2$$

ft. lb. per ft. of crest length. Since the period of the wave is T sec. the energy transmitted per sec. is

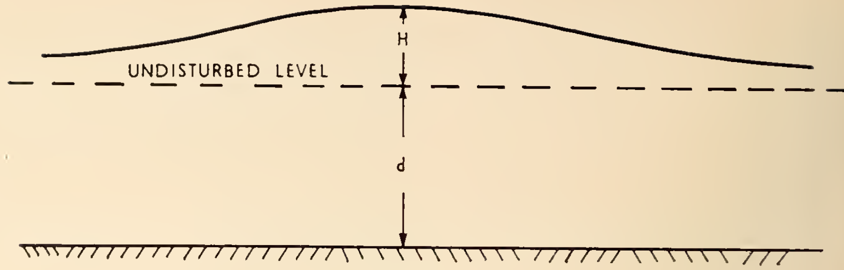
$$1/16 \cdot w \cdot (L/T) \cdot H^2$$

ft. lb./sec. per ft. of crest length. For the wave under discussion (T = 4 sec., L = 80 ft.) *the horse power* transmitted forward is

$$\frac{62.4 \times 80}{16 \times 4 \times 550} H^2 \approx \frac{H^2}{7}$$

per ft. of crest length. If this wave has a height of 4 ft. from crest to trough—a not uncommon height during a moderate storm—the power which must be dissipated is of the order of 2 h.p. per ft. of shore-line. It is little wonder that waves often damage marine structures since so much power is available.

As stated previously, the oscillatory wave, whose profile in deep water is approximately trochoidal, tends to become steeper as it moves into shallowing water and this is accompanied by a flattening out of the trough. In this way its profile becomes more like that of the so-called solitary wave. The 4 sec. period wave in a depth of 16 ft. would have a wave-length of about 72 ft. A solitary wave has been stated to have sensibly all its energy contained in a distance equal to twice the undisturbed depth on each side of its crest—in this case a distance of 32 ft.



PROFILE OF SOLITARY WAVE --DEPTH d TWICE WAVE-HEIGHT H

Fig. 10.

Thus solitary waves would act as such at any spacing greater than 64 ft. Since the crest to crest length of the oscillatory wave would be greater than this, namely 72 ft., it would seem reasonable to liken the action of the oscillatory wave in this depth of water to that of a solitary wave unaffected by the waves preceding or following it.

This postulation has been confirmed by some (but not all) laboratory experiments. It has been suggested that for any given depth of water and height of wave there is a critical period below which the motion is oscillatory and above which the motion is effectively translatory. If the actual wave-period is greater than this critical period the oscillatory waves may be expected to assume the characteristics of a sequence of solitary waves which give rise to pronounced forward displacement of bed material. This critical period may be shown to decrease with the shallowing of the water and also to decrease with increasing wave height for a given depth of water.

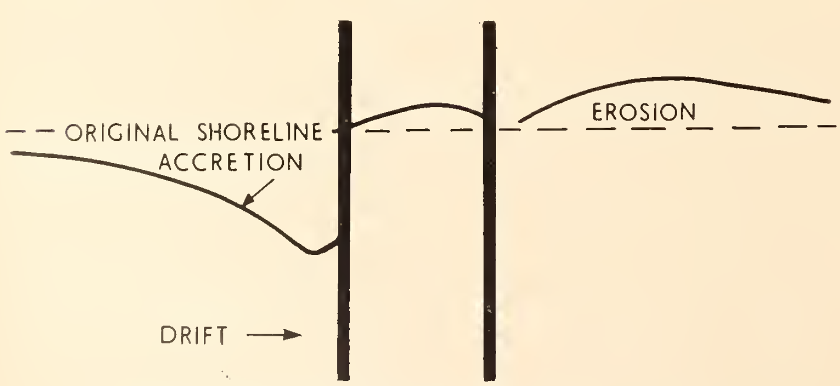
The translatory action would account for the deposits of sand found deep in the harbour areas. It is possible that a storm of a few days' duration, with long period waves acting as solitary waves when they reach the appropriate depth of water, is capable of giving rise to most of the year's deposit. In this connection it is worth noting information in the records of the Department of Public Works concerning the dredging of Port Traverse :

"Average re-dredging per year 1310 cu. yd. During the 1954 contract approximately 2,000 cu. yd. entered the channel during the dredging operations and the dredge was bogged down".

The direction of travel of a deep water oscillatory wave is determined by the wind direction in its generation area and to some extent by the winds farther along its course. If it approaches a sloping beach at an angle, it refracts—the portion of the wave reaching shallower water first slows up, tending to bring the crest into alignment with the underwater contours and the shoreline. As the wave proceeds into even shallower water the lower portion is increasingly retarded by the bottom while the crest becomes steeper and eventually falls forward or breaks, usually when the ratio of wave-height to depth is in the vicinity of 0.7. When the wave breaks an extremely confused and turbulent state of flow exists. The momentum of the breaking wave crest will carry the water up the shore along with particles of sand and gravel. The return flow usually occurs over a longer period, and, as it is not so violent there is a tendency for the heavier particles to remain farther up the beach. This gives rise to the grading of the material on the beach—the finer material being carried farther out.

Because the approaching waves do not usually refract sufficiently to break completely parallel to the shore, swash from the breakers has a component of velocity along the shore and consequently the beach material is carried up at an angle. It is brought back by the return flow in a direction more nearly normal to the shore-line, thus travelling in a zig-zag path along the shore by the process known as beach drift. Since the waves can attack the shore at any angle the direction of this motion in

Fig. 11.



TYPICAL EROSION ACCRETION PATTERN DUE TO A HARBOUR the breaker zone, where most of the littoral movement is thought to occur, may change frequently, but over a period of time there may be a net movement in a definite direction, evidence of which has been presented in Figs. 3 and 4.

It has long been thought desirable to relate the amount of littoral material moving past a given line normal to the shore, which under storm conditions might well be several hundred cu. yd. per day, with the energy or momentum of the oscillatory waves off-shore. Unfortunately an empirical relationship derived for one locations is apt to be incorrect when applied to another. From records of wave height, H, wave length, L and direction of approach to the shore (the incident wave making on angle α with the shore), the long-shore component of energy over a period of time may be computed. The rate of littoral drift may then be written in the form

Rate of Littoral Drift = Constant x L x H^2 x sin α. Unfortunately the so-called constant is far from constant and seems to be affected by some or all of the following factors:

(a). the size and density of the beach material;

(b). the slope of the beach;

(c). a term akin to Reynolds number since certain features of model work do not appear to agree with either larger scale models or prototype results;

(d). the temperature of the water and its viscosity;

(e). the relationship between the oscillatory and translatory nature of the wave prior to breaking.

The knowledge gained from laboratory and field studies will eventually lead to a more complete understanding of the items discussed above.

Remedial Measures

The formation of a beach at the base of eroding bluffs provides a partial barrier to further erosion since much of the energy of the oncoming waves may be spent before reaching such bluffs. Short of sheet-piling the perimeter of the lake the beaches form an indispensable and natural protection for the shores. Drifting of these beaches is inevitable, but so long as the beach is nourished by an amount equal to its annual loss it will maintain a sensibly stable state.

Off-shore breakwaters limit the amount of incident energy striking a beach and slow down the rate of drift in their shadow. Fig. 11 shows the off-shore breakwaters at High Park, Toronto and the accumulation of drift behind them.

Fig. 12. Typical erosion-accretion pattern due to a harbour.

Drifting material in the vicinity of a harbour is the prime source of silt or sand in the navigation channels; Fig. 12 shows the typical pattern at such a harbour. The rate of movement of sand on the updrift side of a harbour may be reduced by the use of groynes. This decreases dredging costs until the groynes fill up with drift material and the whole process starts to repeat itself. Unfortunately, during such a period movement will continue downdrift of the harbour and, since little material is being supplied, erosion of the beach and shore will result.

In lieu of groynes it is sometimes feasible to locate the harbour breakwaters so that the drifting material is carried out into deep water. Failing this it may still be possible, by suitable placing of the breakwaters, to limit the rate of deposition in the navigation channel to something that can be dealt with by occasional as against annual dredging. The rate of erosion of the shore downdrift of the harbour may be so slow that it is not objectionable. If, however, the rate of erosion is serious it may often be decreased by "nourishing" the beach. This nourishing may be achieved by mechanical dumping or by means of a by-passing plant which pumps sand from the updrift or accreting side of the harbour to the downdrift or eroding side.

The control of littoral drift in order to reduce or eliminate damage is often difficult and expensive. The decision on each proposed solution should be based on the ratio of the probable annual benefits to the annual cost.

Inherent in the difficulties faced by engineers in considering remedial measures for the harbours on Lake Ontario is the paucity of information on the following items:

(a). the type of material which moves as littoral drift;

(b). the quantities of material which move as littoral drift;

(c). the wave conditions causing the movement;

(d). the regions and depths where this movement occurs;

(e). the occasions and periods during which significant amounts are moved.

With a thought to the various remedial solutions which have been tried elsewhere, not always with conspicuous success, and the information required both from the field and from the laboratory for their implementation, the National Research Council Associate Committee is proceeding along the following lines with its program of investigation.

Program of Investigation

The field information required to plan remedial measures is

(a). long term wind records;

(b). long term wave records;

(c). long term records of the rate of movement of littoral material.

The information available consists of wind records for the Toronto and Trenton areas which indicate wind speeds and directions by only 45° sectors, aerial photographs and surveys of the shoreline indicating the amount of past erosion and records of the dredging carried out annually by the Department of Public Works. The

(Continued on page 100)

CBC STUDIOS 7 AND 42—
VIDEO AND AUDIO FACILITIES

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CBC Engineering Headquarters, Montreal, Que.

THE CBC'S most modern television studios are the two placed in service in October 1958. Technical facilities for Studio 7 in Toronto and Studio 42 in Montreal had been under installation and planning for nearly a year prior to their opening, and represent the latest in CBC engineering and operational concepts.

Both studios are located in new buildings constructed on property adjoining existing CBC plants. These buildings house, in addition to the studios, shops, storage areas, dressing rooms, makeup rooms and other ancillaries. Both studios have been initially equipped for monochrome, though space is available for conversion to color. Studio 7 in Toronto is 70 ft. wide, 90 ft. long and 40 ft. high. Studio 42 in Montreal is 70 ft. wide, 95 ft. long and 30 ft. high.

Since the video and audio installations for both studios are very similar, a detailed description of the facilities of Studio 42 Montreal will be given first, and later, items of interest which concern Studio 7 alone will be covered.

General

Fig. 1 shows the layout of Studio 42 Control Rooms. The complete length of one studio wall on the second floor level is occupied by the Lighting Control Room, the Announce Booth, the Audio Control Room and the Video Control Room. A video equipment rack area is located off the video control room.

Video Facilities

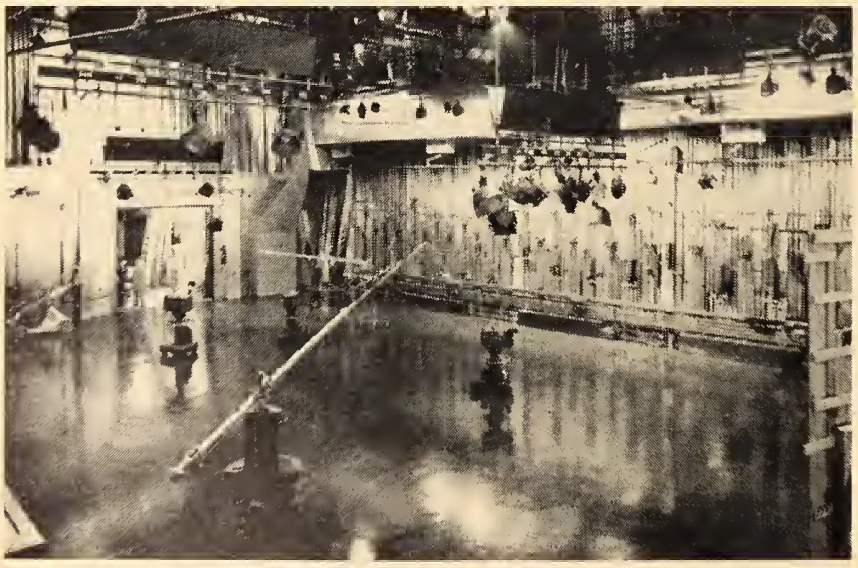
A production desk seating program production personnel, the technical producer and the video switcher operator, occupies the center of the room. In front of this desk is a large window to provide a view into the studio. Immediately below the window, in a well in the floor, are located 17 in. video production monitors which provide the production personnel with continuous monitoring of all cameras, telecine and two line inputs, as well as output, cue, mix and preview.

To the right of the production desk (see Fig. 2) are the camera controls, and on the left of the camera controls is a camera patch panel. Video equipment racks to the right of the production desk, and past the camera controls, house video patching facilities, video and pulse distribution amplifiers and test equipment. Other video equipment, including the video mixer, is housed in the racks which are further removed from the production area.

The camera patch panel is used to connect any one of the four camera controls to any of eight camera bulkhead connectors which are located around the perimeter of the studio (four spare positions can be filled later if required). The four cameras in the studio can thus be connected to the most convenient bulkhead connector and be routed via the camera patch panel to the desired camera control unit. Cable lengths from the patch panel to the bulkhead outlets have all been made the same length. This ensures that no matter where cameras are used in the studio there is no problem with regard to different timing in the video signals at the vision switcher.

For the present, four monochrome cameras have been provided. These

Studio 7 Interior



cameras can be equipped with either 3 in. or 4½ in. image orthicons. Provision is made for the addition of a fifth camera if required. Grating generator signals, fed to the camera controls, may be superimposed on the camera control picture monitor to aid in geometric alignment. The camera viewfinder is normally fed from the output of the camera control unit, but special feeds may be switched in by the camera control operator to assist camera operators in special effects. Picture weave for any camera may be selected and controlled from the vision mixer position. Weave effects are achieved by using an audio oscillator to modulate the camera line scan circuit.

As can be seen in Fig. 3, the output of each camera is fed to a bank of distribution amplifiers which provide feeds to production monitors, the vision mixer, picture match switching and spare outputs for any special requirements. Individual feeds from distribution amplifiers rather than looping or bridging feeds have been provided for the above and other facilities for two reasons. First, the looping and bridging of video lines, especially when the bridging point is far removed from the line termination, may introduce line discontinuities, with consequent reflections and high frequency loss. Second, looped lines do not lend themselves to the rapid replacement of defective equipment without affecting other facilities fed by the same line.

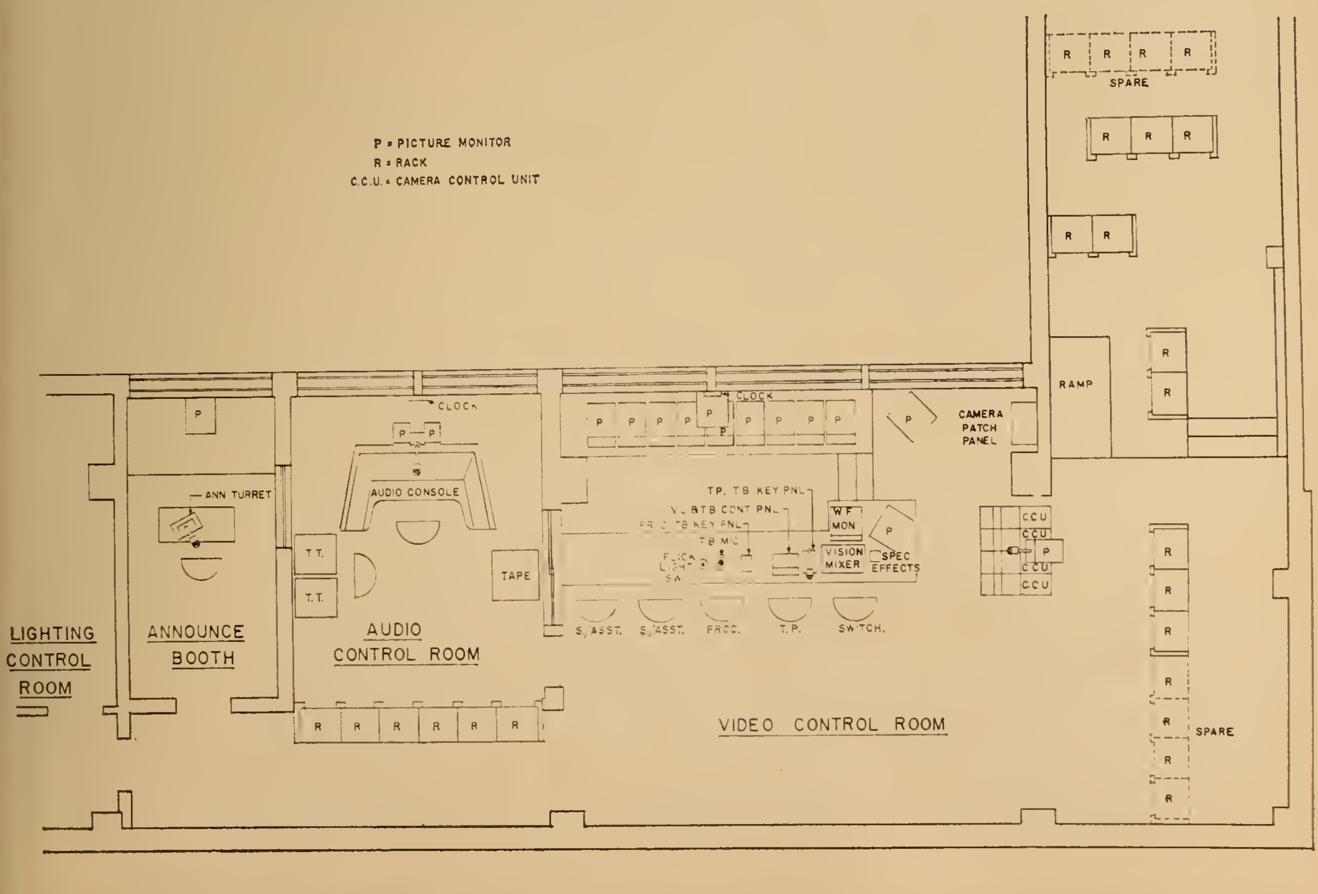
The picture match monitor located at the camera controls permits the visual matching of all cameras on one high quality monitor. Sequential viewing of camera outputs is obtained by push button controls at the camera control operator's position. This monitor can also be switched to a special pre-patched signal and to the studio main output. As with the camera control picture monitor, grating signals may also be superimposed on this monitor by a switch.

Equalized input lines from Master Control cater for telecine, other studios and remotes. These also are routed to banks of distribution amplifiers to permit multiple use.

The vision mixer comprises a control panel and two equipment racks. It will handle twelve inputs and provides one main output, a preview output and two mix outputs. Non-composite or composite, synchronous or non-synchronous signals can be accepted. The switching section of the mixer is a six level, 15 input 6 output video crossbar. One level is used for video switching and the remaining levels for tally, hold, lap-gap and sync non-sync switching. A big advantage in the use of a crossbar for video switching is the relatively low cost and small space required for quite comprehensive facilities. The crossbar itself is compact, and due to its low capacity presents no loading problem even when all video ouptuts are connected to one input. Because of the low loading effect only one standard input amplifier is required to feed each input and it is not necessary to provide isolated feeds to each input, output combination.

The top row of push buttons control the preview bus, and select the output to the production preview monitor and to the switcher operator's master monitor. Selection of any input or any of three "mix" feeds is possible on this bus. The master monitor can also be switched to output by means of the push buttons to the right of the preview buttons. The second row of buttons control the cut bus, and select the signal which is to be switched to the main output, the selection is as the preview bus selection, i.e. any input or "mix" feed.

Fig. 1. Studio 42 Control Room Layouts



The third and fourth row of buttons are known as mix 2 and route any input signal to a mixing amplifier, the output of which is controlled by the two quadrant faders to the right of these busses. The two push buttons between the Mix 2 busses and the fader arms will substitute a special effects unit for the mixing amplifier. The fifth and sixth row of buttons are known as Mix 1 and are similar to the Mix 2 busses.

As mentioned previously, the outputs from the two mixing amplifiers are routed to the "cut" bus as Mix 1 and 2. Additionally, the outputs of these two mixing amplifiers are fed to a third mixing amplifier which is controlled by the fader arms at the far right of the panel. The output of this third mixing amplifier appears at the cut bus as Mix 3. The output of the cut bus feeds a stabilizing amplifier which back porch clamps the signal to maintain correct black level and inserts a local or reconstituted sync/signal.

The toggle switches at the top of the control panel are set for synchronous or non-synchronous inputs as appropriate, and control sync insertion in both the stabilizing amplifier and switcher video monitors. The stabilizing amplifier controls are mounted on the upper right hand corner of the control panel and permit signal adjustment if necessary, though they are normally preset. Non-synchronous signals cannot be handled on the mix busses, but a fade of this type signal on the cut bus is possible by utilizing the stabilizing amplifier "Picture Fade" Control.

Input lines to the vision mixer are isolated from the slight capacitive effect of the crossbar by 6 db. resistive pads. The loss is made up in subsequent amplifiers.

One of the problems in any video switching operation is the avoidance of flashing or transients which may occur during the switch and which may be quite objectionable to a viewer. If it is arranged that there is an overlap of a few microseconds of the two signals being switched, the transition from one signal to another will be freer of objectionable flashing than if there is an actual finite break between the end of the first signal and the beginning of the second. The former type of switching is known as lap switching and the latter, gap switching. In many more complicated video switcher designs there is isolation between the various input output combinations, and no intraction can occur when an input already in use on one output bus is also switched to

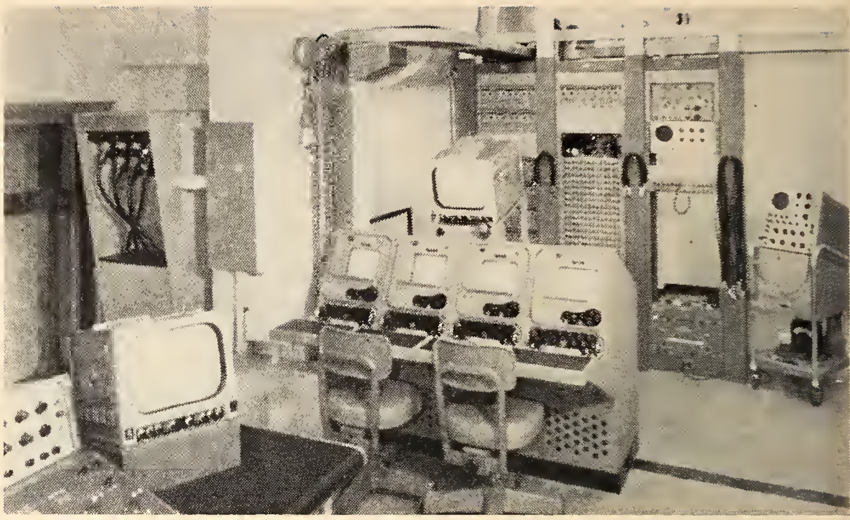


Fig. 2. Studio 42 Video Control Room

a second output bus. Consequently all busses are arranged for lap switching.

In the video crossbar system however there is no isolation between the various input output combinations. If all busses were arranged for a lap switching the selection of an input, on a mix bus for instance, which was already in use on the cut bus, could cause momentary crosstalk and transients. The problem is avoided in this vision mixer by the use of special control circuitry in the crossbar, which is so arranged that the bus which is routed to the switcher output at a given moment will always switch lap and therefore be transient free, while all other busses will switch gap. This arrangement works very satisfactorily since any transients occuring in busses not routed to the switcher output are not important.

The design of the mixer is such that is possible to:

1. Cut from any input to any other input;
2. Fade from any input to any other input;
3. Mix from any synchronous input to any other synchronous input;
4. Superimpose two, three or four synchronous inputs simultaneously;
5. Superimpose two synchronous inputs and a special effects:
6. Cut from any input to any super imposition;
7. Mix from one superimposition to another;
8. Fade from any input to any super imposition or special effect.

The main output from the mixer (see Fig. 3) is fed by and equalized line to Master Control. A second output feeds distribution amplifiers which are used to supply various monitors throughout the studio and the building. Failure of individual mixer components will not completely disable the mixer as patching facilities permit by-passing sections as required.

Video tie lines are provided from the video patch panel on the racks to convenient locations in the studio for cue and special effects purposes.

Pulse System & Sync Locking

There is no synchronizing generator in this studio. Drive, blanking and sync signals are supplied by lines from Master Control. The operation of Studio 42 is linked with the pulse distribution and sync-loc system of the Montreal TV plant. There are four sync generators in TV Master Control. These generators feed drive, blanking and sync signals to a six level 4 input 20 output video crossbar. The generator feeds are terminated at the end of the crossbar and bridging amplifiers are connected to each output. Push button controls in Master Control permit any telecine, or studio, or groups of telecines and studios, to be connected to any sync generator. Three of the sync generators are provided with sync-loc facilities, fed with stripped sync from input stabilizing amplifiers. With the above arrangement it is possible to operate the whole plant from one sync generator, or to sectionalize the plant into groups using different sync generators. An example of operation in Studio 42 could be as follows: Studio 42 and

Telecine 1 are switched to sync generator 1; Telecine 1 video, audio and intercom are patched to Studio 42. Variable delay lines in the pulse feeds in Studio 42 are adjusted to compensate for the time delay in the Telecine 1 feed. Telecine 1 may now be used as a synchronous input to Studio 42. Similarly, it may be arranged for any other local studio or telecine to be used by Studio 42. Should it also be required to use a remote studio, an outside broadcast, or a network program with Studio 42 on a synchronous basis, sync generator 1 is sync-locked to the remote signal, thus making Telecine 1, Studio 42 and the remote signal all synchronous. This sync system is extremely flexible and permits many special set-ups to be made with ease. Requirements for this flexibility arose from CBC operations which involve servicing two major French and English networks, Canadian insertions on American network programs and, in the case of Montreal, the programming of French and English local transmitters.

Audio Facilities

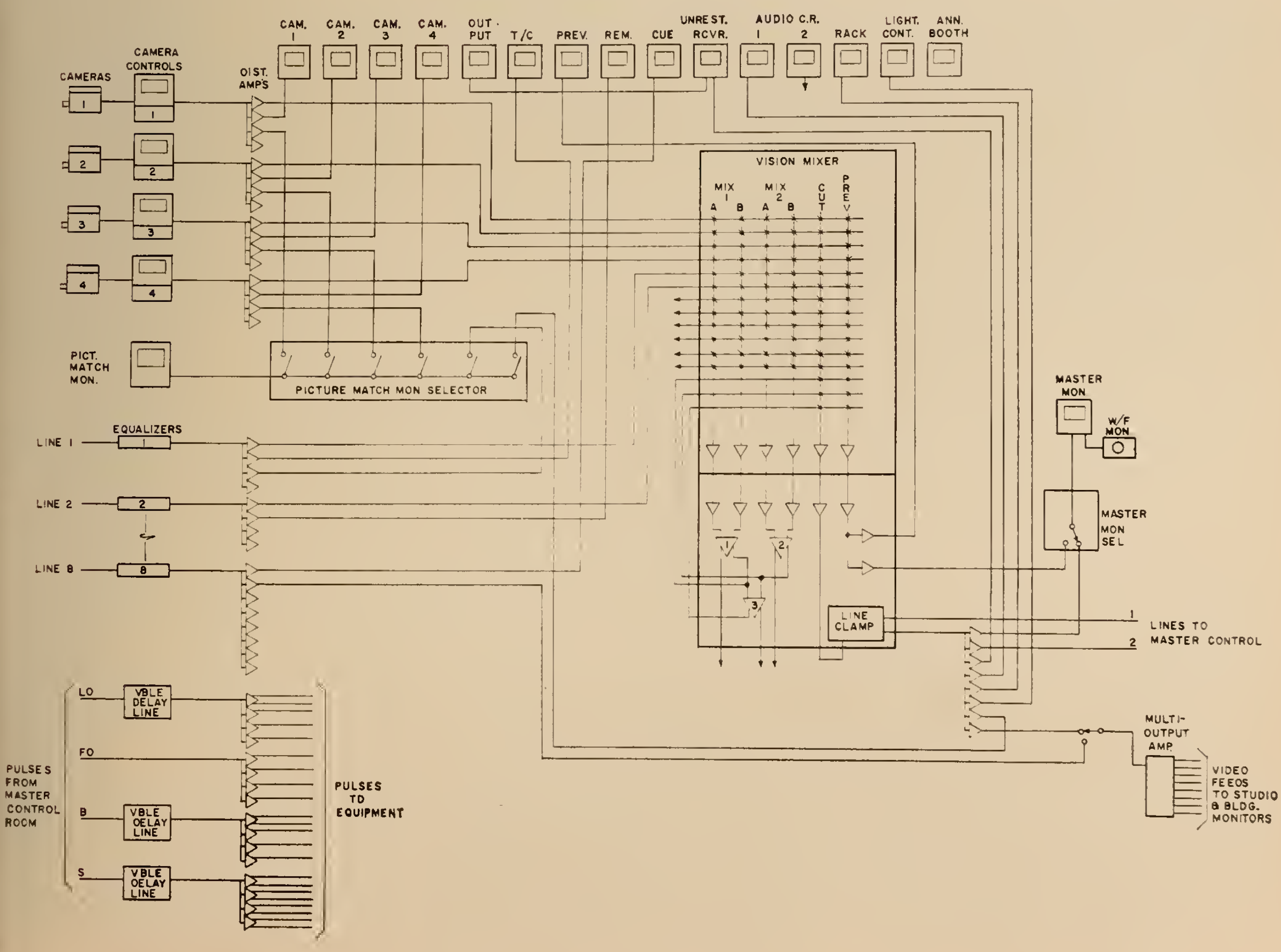
To the left of the production desk in the video control room and separated by a sliding window, lies the Audio Control Room. The audio console faces the studio, with a window to provide a view of the studio floor. Also in front of the audio console are two 8 in. video monitors and intercom facilities. Two turntables and one tape recorder/reproducer are located to the left and right of the console. Be- left of the Audio console and is hind the audio console, and forming part of the back wall of the audio control room, are the audio and intercom equipment racks.

The Announce Booth lies to the equipped with video and audio monitoring facilities and a control turret. The latter permits the announcer to switch his own microphone on or off as desired.

Fig. 4 shows the audio functional diagram. Thirty-eight microphone inputs, from conveniently located microphone connectors around the perimeter of the studio and from the lighting grid, terminate in the audio console. Two turntables and one tape unit feed into the console, from which position they may be stopped and started remotely. Six input lines from Master Control and ten trunk lines to the Studio audio patch panel are also available.

The audio console comprises the control console and two equipment racks. The control console houses terminals, potentiometers, transformers, pads, switches, jacks and "VU" meter, while the racks contain amplifiers and power supplies. The left hand wing houses a console patch panel which permits the patching of any microphone input, turntable, tape machine or line from Master Control into any of 32 console inputs. These 32 inputs are connected to 16 input preselect keys which are located just to the right of the jack panel. Through these input select keys it is possible to route, simultaneously, 16 of the 32 inputs to the 16 preamplifiers. Immediately below the input select keys are 16 submaster select keys. These keys permit allocating any or all of

Fig. 3. Studio 42 Video Functional



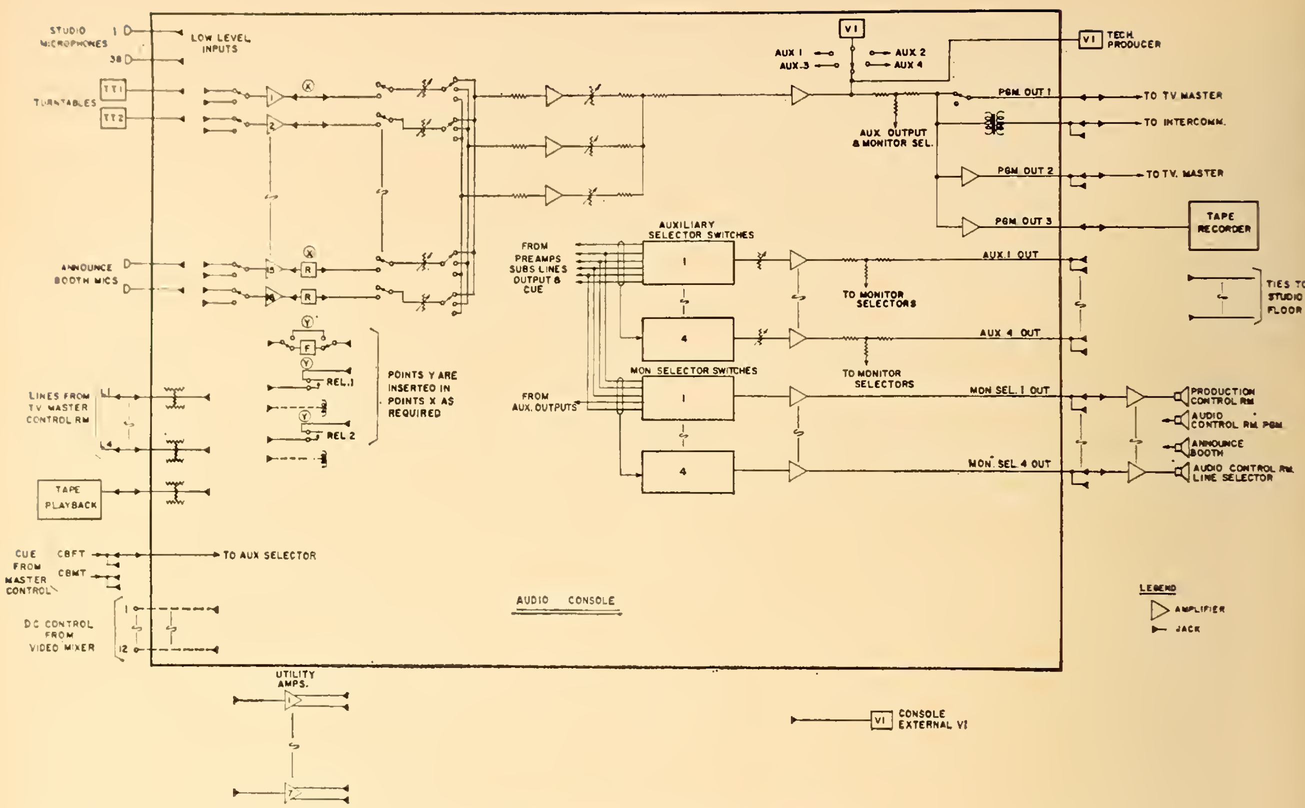


Fig. 4. Studio 42 Audio Functional

the preamplifier outputs to any one of three submaster controls.

The center panel of the console is the main operating area. The lower left and right sections house sixteen potentiometers and associated on-off keys which control the individual preamplifiers. The lower center section houses the three submaster controls known as red, green and amber. Above the submaster controls is a "VU" meter. To the right of the "VU" meter is the master gain control and the output key. To the left of the "VU" meter are the meter select keys which permit monitoring the various console outputs, and further to the left are high and low pass filter controls. The filters may be patched into any desired circuit and used for various effects.

Directly above each preamplifier potentiometer is a frosted glass window which permits the write-in of input designation. This window glows red, green or amber, depending on the submaster to which the particular preamp has been assigned. To the left of each pre-amp on-off key is a small pilot light which is illuminated when the key is on. At the same time, a pilot light associated with the input preselect key, on the left hand panel, is also lit, to warn that the channel is live. The preamp on-off key may also be operated so as to extend remote control of the channel to an announcer.

The right hand wing of the console houses auxiliary output and monitoring controls. There are four auxiliary outputs from the console.

Self-illuminated push buttons, on the right hand panel, permit the routing of any preamp output, any submaster output or the main output, through any auxiliary channel. A gain control is available for each auxiliary channel, and the console "VU" meter may be switched to any channel for signal level monitoring. The auxiliary outputs may be used to feed a reverberation facility, studio floor cue speakers, special recording feeds, public address systems and for other special purposes. The monitor speakers for the control room and studio are also fed from similar switches and gain controls on the right hand panel.

In order that audio inputs may be switched simultaneously with video for special purposes, two special relays have been included in the audio console. Microphones or other inputs can be patched through these relays and will be switched on and off as the relays are operated. Control of the relays may be routed by patching to any one of the video switcher input select buttons on the cut bus. With this arrangement it is possible to have both audio and video switched simultaneously by the vision mixer operator, and thus ensure the synchronism of sound and picture where complicated programming requirements might otherwise cause difficulty.

Intercom Facilities

One of the most important and the most complex of the technical facilities for a television studio is its intercommunication system. It is essential that a rapid flow of information and orders may pass between the control rooms and the multitude of people engaged in a television production. To achieve this end, several methods of intercommunication are used. Personnel, who must hear the producer at all times, are equipped with headsets if located on the studio floor, and with small loudspeakers if located in separate control rooms. They are connected at all times to the producers talkback microphone output. Such people are cameramen, the audio operator, the floor manager and assistants. In the case of the floor manager, a special one-way radio frequency intercom system permits him to receive the producer's talkback without being encumbered by trailing wires. He may talk back to the producer by using special wired intercom microphones, which are available about the studio and connect to the production control room speaker. Of course if the program is only in rehearsal he may talk back through one of the audio microphones. Regular two-way wired intercom headsets are also available for the floor manager, if required.

Other locations such as the studio floor, telecine, remotes, lighting control room and dressing rooms are switched into the general intercom system as the producer requires. The technical producer has facilities duplicating those of the producer, though all are on a switching basis.

The audio operator, also on a switching basis, has facilities for talking to the studio floor, the sound effects operator, the boom operator, telecine, the announcer and the production control room. The lighting operator can communicate with follow spot men and the production control room.

The camera operators have two-way intercom with the camera control operators and are connected to the production control room speaker. All intercom positions are also supplied with program sound, and just prior to the start of the program receive a sound cue from the program preceding. Individual automatic gain control amplifiers have been provided to control intercom microphone levels, and output amplifiers permit adjustment of headset and speaker feeds to standard levels. In addition, each headset and speaker is individually equipped with volume controls, permitting the user to adjust them to suit his own requirements.

Test Equipment

Audio test equipment consists of an audio frequency generator, a noise and harmonic distortion meter and an extended range "VU" meter.

Video test equipment comprises a video sweep generator, a multi-frequency burst generator, a staircase type linearity checker, a window generator, a grating generator and oscilloscopes.

Miscellaneous

The equipment racks used in this installation are a special CBC design, and are ventilated by four ducts which form the four vertical corner members of the rack. Cooled air from the studio ventilation system is fed to the ducts at the top and directed, by circular vents in the inner sloped side of each duct, against the front and rear of rack mounted equipment. Exhaust outlets are situated external to the racks in the ceiling, and remove the hot air from the racks before it can circulate in the room. Conventional room ventilation is also provided. Experience with this type of rack has shown a marked improvement in equipment stability and a reduction in maintenance requirements due to the reduced operating temperatures of equipment. One rack may carry equipment which dissipates up to 4.5 kw. As a satisfactory average it has been found that an airflow of 50 c.f.m. per duct of 50° air is suitable. The ventilation system takes care of an equipment heat load of about 25 kw. in the control rooms.

Video and pulse amplifiers are of the plug-in type, permitting rapid replacement in the event of failure. Additionally, patching facilities for the complete system are so arranged that defective components, whether video or audio, can be rapidly bypassed or replaced.

Hydraulically counterbalanced camera pedestals and a power operated crane, all equipped with a new type springless pan-and-tilt head, have been provided as camera mounts. The pan-and-tilt head is so designed that no matter in what position the camera is placed its center of gravity does not change height, and consequently the camera is always stable.

A new type artificial reverberation unit, which consits basically of a large steel plate with input and output transducers welded to it, has been provided in lieu of the usual reverberation room. Reverberation times varying from one half a second to over five seconds can be remotely selected by the audio operator. From limited experience to date this unit appears to be much more satisfactory than the rooms usually provided.

Studio 7 Toronto

As noted previously, the Studio 7 installation in Toronto is essentially the same as the Studio 42 installation just described. An additional facility provided in Studio 7 is a separate Sound Effects Room with special turntables, tape machine and small audio console. This permits recorded music and complex effects to be routed as a single input to the main audio console. In Studio 42, sound effects are usually obtained from the studio floor.

An interesting problem arose in connection with the Studio 7 video installation. The building in which Studio 7 facilities are housed is a separate unit from the main TV plant, and separated from it by about 100 ft. Two separate power entrances and watermain entrances serve the two buildings. Early in the project it was found that the ground potential between the two buildings was of such magnitude that when a video signal was fed by coaxial cable from one building to the other, the longitudinal noise voltage was on occasion so severe as to make the video signal unusable. Several avenues of investigation toward a solution were open, but the simplest appeared to be to prevent the difference in ground potential from inducing an unwanted voltage onto the video signal. Fortunately a device known as a longitudinal stop coil, produced by a British firm, was available for test. This stop coil consists of a coaxial cable about 100′ long wound in a toroidal form on a magnetic core. Stop coils have been placed in all coaxial cables joining Studio 7 to the TV Master Control, and entirely eliminate hum voltages up to approximately 10% of the video signal.

As noted above, Studio 7 is in a separate building to the TV Master Control, and all video audio and intercom circuits connecting the two locations are carried by a special messenger cable which joins the two buildings. Video and pulses are handled by two specially constructed cables each made up of ten coaxial cables with an overall covering of polyethylene. Audio and intercom are handled by two 26 pair telephone type cables also provided with a polyethylene covering.

Acknowledgements

In projects of this size it is obvious that dozens of individuals have played an important part in the design and installation work, and it would not be feasible to acknowledge their contributions individually. Thanks are due to Mr. W. G. Richardson, CBC Director of Engineering, for permission to publish this paper. and to the CBC Chief Engineer Mr. J. E. Hayes and the Plant Engineer Mr. J. Carlisle, under whose supervision the work was carried out.

SOME FUTURE DEVELOPMENTS IN THE TELEPHONE INDUSTRY

S. G. Anderson

SINCE THE ARRIVAL of nationwide network television in Canada, much has been said about our Trans Canada Microwave Network. This system known as the TD-2 Radio Relay System, operates in the 4000 mc band and is capable of carrying 3,000 telephone circuits or five 2-way T.V. network channels over distances of 4000 miles. Remarkable as this is, a system now undergoing trials operates in the 6000 mc band and will be capable of carrying up to 13,320 telephone circuits or six 2-way T.V. channels over distances of 4000 miles.

Looking further into the future, we know that if a stable extremely high frequency signal of say 50,000 mc could be generated and this propagated by some means between two points without undue loss, that a very large channel bandwidth can be obtained. This radio frequency carrier can be used to transmit a multitude of T.V. channels and many thousands of telephone circuits. (Table 1)

Both the TD-2 and TH Systems make the maximum possible use of the available frequency spectrum (i.e. 3700-4200 and 5925-6425), assigned by the Department of Transport. Now let us assume that equipment operating in the 50,000 mc band was available for use, add this to our table and see what circuit capacity we have in hand. Assuming the same percentages in frequency spectrum and channel spacing as for the TD-2 system, and assuming 25% of the available channels are held for protection purposes, we find 61 working channels available for message use. At 2200 telephone circuits per RF channel, this system would provide us with approximately 133,000 telephone circuits, or 61 2-way television channels. Even the most avid T.V. fan would consider this number of T.V. channels adequate.

The next question is: how do we transmit a 50,000 mc signal from city to city? Since this signal is too high in frequency to travel through the atmosphere without extreme attenuation, experiments are underway in the Bell Telephone Labs. to determine if this signal can be successfully transmitted down a hollow pipe or waveguide using a certain mode of propagation in the waveguide (TE01) . . . We can visualize our cities of the future connected together by a network of communication pipes with repeaters every 40 miles or so amplifying signals of 50,000 and perhaps 100,000 mc.

By utilizing the vast communications highway that is being established across the country, operators have been able to dial directly to numbers in distant cities in all parts of North America. Already in some parts of North America, telephone users are able to dial their friends in distant cities directly, without the help of an operator. With each succeeding year many more will be able to dial their own long distance calls to many of the 65 million and more telephones in Canada and the U.S.A.

The present type dial on your telephone operates equipment by interrupting a d-c. loop between your house and the telephone office at the rate of ten impulses per second. On long distance circuits however, it is not possible to provide d-c. paths to operate equipment and multi-frequency tones are employed.

With the multi-frequency pulsing system, six frequencies spaced 200 cycles apart from 700 to 1700 cycles are used. Two of these frequencies are used for each pulse and each pulse represents one digit. There are 15 pairs possible from a group of 6, and 10 of them are used for the digits 0 to 9 inclusive. One each is used for signalling the beginning and end of pulses. These multi-frequency tones can be sent out over the toll line by means of what we call sender equipment in the toll office. The operator causes this sender to function by pulsing into it with d-c. key buttons. Such senders store the pulses and re-transmit multi-frequency pulsing signals to the toll line at the rate of seven digits per second. (2L-5N number is transmitted in one second).

The average speed of keying by an operator is two digits per second, which is about twice the average speed obtained by the dial. This speed of keying along with the rapid transmission rate of these signals along the toll circuit, represents a large saving in operator and circuit usage time. The day may come when this little key set will replace the present dial on your telephone.

We are now thinking in terms of world wide communications. Late in 1956, the first Trans Atlantic telephone cable went into service between Europe and North America.

It provides 29 telephone circuits between London and New York, and six between London and Montreal. Seven of the New York and London circuits have been extended to continental network centers.

From Oban, Scotland to Clarenville, Newfoundland, transmission is over a deep sea submarine cable system. This link makes use of two cables, one for each direction of transmission. The cables are laid approximately 20 miles apart and they are 1,950 miles long, submerged at depths up to 2½ miles. 102 repeaters, 51 in each direction, are used to compensate for the cable attenuation. The repeaters are enclosed in flexible housings within the cable and were designed to pass through the ship cable laying machinery. At the same time they had to be strong enough to withstand the deep sea pressure of 6,000 lb. per sq. in.

From Clarenville, Nfld. to Sidney Mines, Nova Scotia, a single coaxial cable having a capacity of 60 circuits was laid. Sixteen repeaters were required in this section.

The idea of a submerged telephone cable is not new. Non-repeater telephone cables have been in existence for many years. The fact of great significance in the laying of this cable is that the 300 and some odd vacuum tubes and many other thousands of components must have a reliable life of at least twenty years, without maintenance.

Plans are underway to lay a British-Canadian cable having a 60 circuit capacity, and an additional cable to link Continental Europe with the U.S.A.

Miniaturization is of especial importance in the improvement of telephone service. When something smaller can do as good a job or better than the equipment it replaces, there are often important savings to be made, not only in material but also savings in space and power requirements. One of the best examples of this research is the work that has been done in the Bell Telephone Laboratories in the semi-conductor field, producing such items as the Solar battery, photo-transistor, and transistor-amplifiers.

The heart of the Solar battery is the *p-n* junction or boundary between different electrical conductivity types in a semi-conductor crystal. Light energy when it strikes a semiconductor will often split off an electron from its normal position in the crystal lattice, leaving a positively charged hole in the vacant space. Both the electron and the hole will then be available for the conduction of electricity—if they can be prevented from re-combining and thus neutralizing each other. The *p-n* junction provides a built in electric field, that pulls the electrons into the *n* or negative side of the junction, and the holes into the *p* or positive side before many of them recombine. The electrons and holes are said to be collected by the junction. With suitable contacts and leads to the two sides, the resultant current can be used in an external circuit.

There are five important facts about the Bell Solar battery that are really worth emphasising:

(1) It is an experimental device that converts sunlight directly into electrical power with no intermediate steps;

(2) It is at least fifteen times more efficient than the best previous solar energy converter, having an efficiency of 8% at present;

(3) It has no moving parts or corrosive chemicals and should last indefinitely;

(4) Its efficiency of conversion of available light remains essentially constant, even in poor light where other converters will fail;

(5) It charges the storage battery at constant voltage, and a solar battery-storage battery combination can thus average a steady power output day and night.

Semi-conductors can also be used as photo-conductive devices in which the conductance of a semi-conductor element is increased when the element is illuminated. This is a principle employed in the photo-transistor, and this little device is used in nation wide dialing in routing calls through offices. This routing information is registered on metal cards with holes in them, the cards to be selected in accordance with the digit dialed. The cards are stacked together and a light is shone on them.

Photo-transistors are used then to determine what light channels are blocked or clear, by causing the operation of a relay, thus supplying the routing information.

The transistor as an amplifier is essentially two *p-n* junctions located very close together. One junction (emitter) is biased by a battery in the forward direction; the other junction collector is biased in the reverse or very high resistance direction; and the small current which does flow is due only to the small number of minority carriers which are always present in a semi-conductor near the junction.

A very small signal in the emitter circuit will produce a corresponding current across the emitter junction. As a result, minority carriers (electrons) are emitted into *p* type base layer. Due to the dimensions of the base layer almost all emitted electrons will reach the collector junction before they find their way out to the contact at the base, or are lost by re-acting with holes. Since there is very little current flow in the collector circuit due to this high resistance, the introduction of the unattenuated signal from the emitter results in a large increase in power, and the energy of amplification is furnished by the battery B2.

Hence transistors have many advantages:

(1) They require practically no power to run, operating on 2 to 4 volts only. Thus in the telephone companies, where thousands of vacuum tubes are now used requiring larger amounts of power, the introduction of the transistor amplifier will represent large savings;

(2) They are very small in size, permitting miniaturization of components which represents a large saving in equipment space;

(3) They have a long life expectancy due to the fact that electrons are not being emitted from material as in the case of the vacuum tube.

City-wide personal radio signalling is a potential new service now being tested in the telephone industry. The system serves to indicate to a particular customer, perhaps a doctor or salesman, when his secretary or some other party is trying to reach him. The customer carries a small radio

Table 1

	Frequency Spectrum Mc	*D.F.S.*	*RF Channel Bandwidth*	*RF Channel Spacing*	*No. of RF Channels*	*RF Channels left for Message use*	*No. of Protection Channels*	*Telephone ccts/ch.*	*Total Message ccts. per system*
TD-2	3700—4200	500 mc	20 mc	40 mc	12	6	1	600	3,000
TH	5925—6425	500 mc	28 mc	29.6 mc	16	8	2	2200	13,320
TX	50,000—56,500	6500 mc	20 mc	40 mc	162	81	20	2200	133,000

receiver, completely transistorized and only slightly larger than a package of cigarettes, in his pocket or clipped to his belt.

On receiving a radio signal with the proper code, the radio will emit an audible tone of sufficient loudness to inform the user that he is being called. He then goes to a telephone and calls his office where he is given the message.

To call a customer the person dials a particular telephone number and is connected with a personal signal operator. The calling party gives the operator a four digit number which corresponds to the code associated with the radio receiver assigned to the called party. The operator then places this number into a memory system by setting up a series of four rotary switches. The codes set up on the switches are scanned and translated into components of four audio frequencies. The audio frequencies modulate a 250 watt A.M. transmitter which operates on one of the common carrier mobile frequencies.

When the radio frequency signal is picked up by the receiver, it is demodulated and the audio tones are used to energise a group of four vibrating reeds. If all reeds are energised, an audio oscillator is triggered and an alternating tone informs the customer that he is being dialed.

The units are small and light in weight and employ a single 4 v. battery.

It is estimated that ranges of about two to four miles from each transmitter will be obtained. To compensate for variations in radio propagation, any given code is transmitted three times.

There are also some changes in store for your telephone. At present there are long range plans underway in telephone laboratories to convert from a mechanical type dial switching to electronic type dial switching systems by extensive use of the transistor. This conversion will necessitate many accompanying changes, one of these will be the replacements of the familiar bell ringing signal by an electronically generated musical tone. At present 90 v. of 20 cycle power is required for ringing the present bell. A tone ringer superior in output to the conventional ringer and more pleasing to the ear has been designed through use of voice frequency tones of less than 1 mw. This employs a transistor amplifier and small speaker in the telephone set. By using different frequencies on the line and resonant circuits in the telephone, telephones working on a party line basis may be rung individually. Tests have shown that the musical tone can be heard at great distances and stands out above general room noise more effectively than the present bell.

Other changes in the telephone may include replacing the dial with a key punch. The hand set itself may eventually be replaced by a small microphone and speaker, permitting operation with the hands free.

We may in the future have a telephone that transmits pictures as well as sound. In the experimental models that have been developed, the pictures are 2 in. by 3 in. in size. Unlike television, a new picture is displayed every two seconds. The picture phone has been made possible by slowing down the rate of transmission of picture information, so that the required band width can be handled by conventional telephone circuits (300-3400 c/s). The illuminated area of cathode ray tube is made up of 60 lines, each line containing 40 dots. Thus a complete frame is made up of 2400 dots. If one complete picture is transmitted every two seconds, a bandwidth of 600 cycles is required.

In order to pass the low frequency components of this 600 cycle band over telephone facilities, this video signal is modulated on a 1200 cycle carrier, and produces a conventional A.M. double side band signal (600-1800 c/s). It will be possible for a caller's picture to be dialed like an ordinary telephone call, provided the switch (and there must be a switch) on the picture equipment is turned on at both ends of the line.

Today the telephone companies have a growing list of new users who are not people but electrical and electronic business machines. Such machines talk to each other at very high speed over long distances.

A data transmission device has been developed which has been an important step in the transmission of data over telephone lines. This device takes the information after it has been placed on a magnetic tape and transmits it over telephone facilities.

For example, a secretary in the headquarters of a power firm has a two page, thousand word document which must be delivered to an outlying office. The desk in front of her has an electric typewriter which produces type and magnetic tape for use in the subset. She establishes the call in a normal long distance manner, places the tape in the machine and transmits the thousand word document in less than a minute.

LITTORAL DRIFT *(Continued from page 91)*

only wave data available would be hind-cast records built up by tedious calculation from synoptic charts.

In an effort to determine some of the necessary facts it has been decided to gather data initially at two typical harbours, Cobourg and Port Hope. Complete hydrographic surveys have been made at each of these harbours and range lines established along which soundings are taken monthly in an effort to determine the rate of accretion or depletion. The measurement of waves has been achieved by setting up a pressure-cell recording device in 40 ft. of water 4,000 ft. off shore at Cobourg, with automatic recording in an instrument house on shore. This distance offshore was deemed necessary to avoid the reflections set up by the breakwaters nearer the shore-line. The pressure type wave recorder was designed and installed by the Instrument Section of the National Research Council and has been recording the wave action every three hours since last February. A recording wind gauge has also been installed at Cobourg to operate in conjunction with the wave apparatus.

A wave flume has been designed and constructed in the hydraulics laboratory at Queen's University. It is at present being used in a basic investigation of the transporting properties of various types of waves.

When sufficient field information about the wave characteristics, the rate of littoral drift and the rate of deposition in existing harbour channels has been accumulated, it will be possible to construct models of actual harbours and attempt to adjust the operation to reproduce existing conditions. Proposed changes such as deepening of channels or extension of breakwaters could then be tried out at the model scale in an effort to predict prototype behaviour before the changes are made.

No. 9
of a Series

INSTRUMENTATION IN INDUSTRY

CHEMICAL PROCESSING PLANTS

THE GENERAL requirements for controlling and recording instrumentation in the chemical processing industry are quite similar to those prevailing in the petroleum refining, gas processing, and particularly, petrochemical fields. Processing is here taken to cover the making of desired end-products by a continuous series of chemical and physical processes, usually in liquid or gaseous phases, rather than the intermittent batch processes or electrolytic methods used in the production of some heavy chemicals and dyestuffs, or the final blending of materials.

The processing industry could not function without the use of instruments to record and control such variables as temperature, pressure, flow rates, liquid levels. The efficiency of processing is further increased by the use of instruments for the continuous measurement of pH, chemical composition, specific gravity, and so on. Additional refinements may include the use of continuous measurement of corrosion within lines or vessels.

The complexity of instrumentation naturally varies with the size of the plant and the processes involved, but there is a notable trend towards full automatic control and the release of operators from routine checking to devote more time to improvement of production. Apart from the automatic operation of pumps, valves, feeders, etc., stream conditions can be constantly checked by such techniques as thermal conductivity, gas chromatography, and infra-red analysis.

Power Supply

The chemical processing industry in Canada relies almost entirely on main electrical power purchased from outside suppliers. In only a few cases is this supply checked independently by the user, though the individual circuits within the plants naturally have their own regulating and measuring systems.

Who Determines Instrument Requirements?

All companies that replied to a questionnaire on this subject have instrument requirements determined by a member of the engineering staff, frequently an instrument engineer. This is particularly the case where the company controls its own process design and has reason to keep information secret. Maximum efficiency may be better obtained by selection of individual instruments on their own merits, rather than going to one manufacturer for all requirements.

Who Buys the Instruments?

In nearly all cases covered by the questionnaire, the engineering department (usually an instrument engineer) has the responsibility of specifying the types of instrument required, but the order to the supplier is placed through the purchasing department.

One large manufacturer stated that the instrument buyer has to be familiar with the equipment and well qualified to evaluate competitive quotations. He attends training courses run by the instrument makers and visits their plants so as to acquire a good overall knowledge of what is available in the instrument field.

Servicing of Instruments

Replies to the questionnaire indicate that at least 90 per cent of replacement, service, repair, and recalibration of instruments is carried out by the processer's own staff. Exceptions noted include small plants that do not carry the necessary staff, but send instruments to the manufacturer for repair and recalibration, and certain cases of specialized instrumentation.

No specific data are available on the use of preventive maintenance throughout the industry, but it is probable that some form of preventive system is prevalent for the same reasons that it is used in the petroleum refining industry.

Maintenance staffs obviously vary with the size and complexity of the plant, and may consist of one instrument mechanic for a relatively small organic chemical processing plant. A more diversified organic chemical plant with an initial instrument installation costing over one million dollars maintains some 2,000 instruments: there are four instrument mechanics plus one man for regular shop repair and overhaul, and an electronic technician to service electronic equipment. In one large plant, operating under severe conditions, twelve mechanics are used on day shifts to maintain instruments which have an installed value of over $1.5 million.

Spare Parts Practice

Practice in handling spare parts again appears to vary with the type of plant and other conditions. Probably, the smaller and simpler the instrument installation, the less tendency there is to hold a stock of complete replacement units, though all replies indicate that some spare component parts are held for essential repairs and replacement.

Instrument Specifications

It appears to be general practice for the chemical processors' own engineers to specify the instruments to be used in an installation. The industry also generally uses 'standard' instruments, of which a wide range has been developed to meet the varied needs of the chemical processing techniques now in use.

• INSTRUMENTATION

Statistics on Instrument Usage

Capital costs of instrument installations vary widely with the size and complexity of the plants involved. It is difficult to attempt any comparison between capital investment in instruments and volume or value of product, since a relatively small output of one chemical product may have a high dollar value per unit, whereas another may be produced in much larger quantities for a smaller unit value. At the same time, there is no simple relationship between complexity of instruments, gross throughput of plant, and value of end-product.

Installed cost of instruments for a one-product plant (organic chemicals) might be of the order of $20,000 to $25,000, with an annual maintenance cost of four per cent to fifteen per cent of installed investment. A multi-product organic chemicals and resins complex with installed instruments to a value of just over $1 million reports an approximate breakdown of initial installed instrument cost as: one-third for raw materials processing and utilities; two thirds for chemical and resin processing. The question of recovery time for instrument investment is largely academic in the chemical processing industry, since most processes are virtually inoperable without certain basic recording and control instruments.

Types of Control

Opinion of chemical processers is divided on the subject of pneumatic versus electronic control systems. Generally, pneumatic controls have prevailed so far in the Canadian chemical processing industry, but the use of electrical transmission circuits and electronic controllers is now being more widely investigated. The main objection to electronic controls is the need for special precautions if they are used in potentially explosive atmospheres.

Advanced Instrumentation

As already mentioned, there is a growing tendency to incorporate refinements into processing plants beyond the basic essential control and recording instruments. In particular, it is now becoming possible to keep a constant check on constituents in process streams by the use of industrial-scale vapour-phase chromatography, infra-red analysis, and analysers for oxygen and combustible gases, plus pH measurements on liquids.

Ultimately it will be possible to feed such information, together with data on such variables as temperatures, pressures, flow-rates, levels, catalyst efficiency, etc., to a computer system which would regulate all the interdependent conditions to give maximum process efficiency far more rapidly and consistently than is possible with the intervention of human operators.

This degree of control has already been achieved on an experimental scale in a chemical plant in the United States.

J. B. Birks, B.A., Ph.D., D.Sc., F.Inst.P., A.M.I.E.E., reader in physics, Manchester University. (co-author of the paper, "Capacitor Developments in Great Britain", in our July issue).

Dr. Birks was Research Manager of British Dielectric Research Limited from 1954-57. He is the editor of "Progress in Dielectrics" and the author of 50 published papers.

We offer our sincere apologies to Dr. Birks for omitting this relevant information and stating his academic qualifications incorrectly in our earlier biographical note.

It was erroneously stated in the June issue of *The Engineering Journal* (Authors page) that Mr. R. M. Bremner *(3,500 ton University of Toronto Building Moved 250 Ft.,)* was in charge of construction and planning at the University of Toronto. Mr. Bremner is, in fact, an assistant in the department and the staff of *The Engineering Journal* apologize for any inconvenience or embarrassment caused.

HEADQUARTERS

COMPUTATION CENTRE FOR

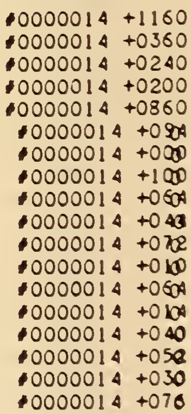
THE H.E.P.C. OF ONTARIO

The Design of the Data Communication Network

by W. H. Sanders

The table at the foot of page 46 was set in type, since we did not feel that the illustration as submitted to us would reproduce well. But as the author has now pointed out, the overprinting which could not be set in type was essential to indicate an error condition. This is shown in the accompanying illustration, with our apologies for having overlooked it in the first place.

section of table showing over printing



WANTED

June 1959 issue of THE ENGINEERING JOURNAL

The Engineering Institute has received so many requests for additional copies of the June 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, Que.

We offer our sincere apologies to Mr. C. C. Parker, whose name was misspelt in our August issue (Discussion on the paper—Design and Erection Features of the Vertical Lift Bridges for the St. Lawrence Seaway) by W. F. H. Holt, M.E.I.C.

Canadian Developments

1959 Coast-to-Coast Surveying

Mapping of Canada

The federal mapping and charting program for 1959 has been under way since May and will continue until November. The program will take survey parties to all ten Canadian provinces as well as to Yukon, Northwest Territories and coastal and inland waters. Included in the field survey force of more than 1000, there are 81 individual survey parties and 28 units of the Canadian Hydrographic Service.

Mines Minister Paul Comtois said that emphasis is being placed on the development of the northland. The objectives are: the long range purpose of providing Dominion-wide coverage in base maps and charts at various scales; and the short range objective of gaining knowledge of potential resources of minerals, water power and forests. Defence needs are also aided by the mapping and charting program.

Public Works

Harbour Improvement: The contract has been awarded at over $3 million to MacNamara (Quebec) Limited for a large harbour improvement project at Pointe-ou-Père, Quebec. The result will be a good winter port on the Quebec South Shore and better traffic facilities for the developing North Shore.

The improvements will include a widening of the existing wharf to 200 feet. There will also be an extension to the existing wharf, which will be 710 ft. x 75 ft., and new approaches on the east and west sides. Dredging of 54,000 cu. yd. is necessary for berthing and turning areas.

Bridges: Poole Construction Company of Calgary have received a $2 million contract to build bridges over the Pelly and Stewart Rivers, Y.T., and to improve the Yukon River Bridge at Carmacks.

The Pelly River and Stewart River bridges are on the Whitehorse-Mayo Highway, 160 and 220 miles north of Whitehorse respectively.

A bridge will be built between Campbellton, N.B., and Cross Point, Que., and a $2.9 million contract was awarded for construction of the superstructure has been awarded to the Canadian Bridge Division of Dominion Steel and Coal Corporation Limited, Walkerville, Ont.

The two provincial governments and the federal government are jointly financing the project, which will replace a ferry crossing and avoid a 26 mile drive around the Bay of Chaleur. Work is already progressing on the substructure.

Atlantic Provinces

Construction in 1959 in the Atlantic Provinces will exceed the 1958 program in volume, and approximately 11% more will be spent on construction than in 1958, according to a Canadian Construction Association report of forecasts.

All of the Atlantic Provinces with the exception of Newfoundland; will noticeably increase volume of construction bringing per capita spending for this purpose closer to the national average. The highest rate of activity is in New Brunswick, then Prince Edward Island and Nova Scotia.

Canada's $7.2 billion estimated program for 1959 will represent a small decrease from 1958, and a per capita spending of $415. The Atlantic Provinces volume of $499.6 million represents a $270 expenditure per capita.

Ontario Frequency Standardization

Ontario Hydro have completed the 10-year frequency standardization program ahead of schedule. Well over one million customers now receive 60-cycle in place of 25-cycle power. Estimated cost of standardization was $360 million. It is estimated that this outlay will be recovered in approximately 20 years through savings directly resulting from the change.

Work on Victoria Bridge

A 130-ft. girder-type span weighing 60 tons was put in place recently on Victoria Bridge, Montreal, by C.N.R. in an unconventional engineering job.

Trucks moved the span 2,000 ft. over the bridge to its final location. Later the span was lowered into place and old sections were removed.

The girder-type spans are required to replace two of the present truss-type spans, which must be removed to allow a diversionary rail and road route to be joined to the existing bridge structure. This is the fourth and final girder-type span to be installed in the downstream side. Next year, spans will be replaced on the upstream roadway, and later, on the rail route. Construction is to be completed in 1961.

Building in Winnipeg

The new head office of the Great West Life Assurance Company was formally opened in Winnipeg, Man., in June.

The building is on an 8-acre site. It is a T-shaped structure of 5 storeys with a 2-storey penthouse. Frontage on Osborne Street is 758 ft., depth is 283 ft., and height, 99 ft. Floor space is 219,000 sq. ft.; capacity is 1,600 persons (addition of five-storey wing will increase capacity to 3,200).

Piling consists of 198 caissons to hardpan bedrock, averaging 55 ft. below street level; 7,000 cu. yd. of concrete; 800 tons of reinforcing steel and 1800 tons of structural steel were used.

Year-round climate control is provided, and three 300-hp capacity oil fired units produce 30,000 lbs. of steam per hour for forced hot water heating through converters.

Turbine Export to U.S.

Dominion Engineering Company Limited of Montreal, is to supply ten Kaplan type hydraulic turbines, to be installed in the Wanapum Development on the Columbia River in the State of Washington. Each of the turbines will have a rated capacity of 120,000 hp., when operating under 80

• CANADIAN DEVELOPMENTS

ft. head at a speed of 85.7 r.p.m. They will be among the largest units of this kind in the world.

This is the company's debut into the U.S. hydraulic turbine market, though Dominion turbines are operating in Brazil, Russia, Ceylon, Pakistan and New Zealand.

Natural Gas Future

"Tremendous gas discoveries during the past year" in British Columbia were mentioned recently by Dr. George S. Hume, vice-president and chief geologist of Westcoast Transmission Company Limited.

Indications now are that British Columbia may have reserves in excess of 60 trillion cu. ft. of natural gas, while further large reserves may lie in the north, he said.

Requirements of 350 million cu. ft. per day for the current period will rise to 640 million cu. ft. per day in the 1962-63 period, and 835 million cu. ft. per day in the 1964-65 period, the company estimates.

Alberta Industries

Fibreboard Plant: The Province's first rigid fibreboard insulation plant, built at Wabamun by Fibreboard Manufacturing Limited, went into operation early in 1959, with an estimated eventual production value of $1 million annually.

A new industry at Fort Macleod manufactures an all-purpose winch and hoist called the Giant Hand. Production capacity is 25 to 30 units per day. The company plans to arrange national distribution of its product.

Inventors say it is the only tool of its kind made in Canada, and compares with imported models, though lighter in weight. With a weight of only 13½ lb., it has a lifting or pulling capacity of one ton.

Export of Mine Hoists

An American steel producer is buying Canadian Westinghouse mine hoists for a new iron mining development in Missouri. The hoists and braking system, slated for installation in 1960 (Koepe friction hoists and pneumatic disc braking system), represent the largest and first export to date of this equipment.

Westinghouse is also working on an export order for five giant power transformers for the Tacoa power project near Caracas, Venezuela. Shipment of the first is scheduled for September.

Nuclear Power Plant

A site is being sought for Canada's first large-scale nuclear power plant, and there is some interest in a site near Kincardine, on Lake Huron.

The agreement was reached in June, between Ontario Hydro and the Atomic Energy Control Board, that full scale work on a 200,000-kw. plant will be undertaken. The $60 million project is intended to be in service in 1964-65.

Ontario Hydro, who will staff the plant and buy the power generated, will eventually buy the plant for the Hydro system.

New TV Relay

The BBC Engineering Division has developed a system for transmitting brief television news picture sequences and other short television film sequences of up to one minute's duration over a circuit of the transatlantic telephone cable normally used for sound. These picture transmissions can be sent over the cable in both directions.

The development was first used to cover the visit of Queen Elizabeth to Canada, allowing swift transmission of departure and arrival pictures to Canada and to Britain. Films of the opening of the St. Lawrence Seaway by the Queen were also transmitted by the new system, the development of which makes use of an altogether new technique.

The process employs a slow-speed flying-spot film scanner, and uses the video signal from it to modulate a carrier for transmission over the cable. At the receiving end the signals are demodulated and used to operate a slow-speed film telerecording equipment.

Saskatchewan Industries

Steel Mill: Progress of the big rolling mill of Interprovincial Steel Corporation at Regina, points to completion of the $15 million mill on schedule, January 1960.

Gas Plant: Liquid Carbonic Canadian Corporation Ltd. has announced plans for the construction of a 750,000 industrial plant at a site adjacent to the Interprovincial Steel Mill, at Regina. The plant will supply oxygen to the steel mill through a direct pipe line, the mill using 1.5 million cu. ft. per month. The plant will also manufacture industrial gases.

Cement plant expansion: A $1 million expansion of its Regina plant is planned by the Saskatchewan Cement Company. This development will ensure adequate supplies of cement for the South Saskatchewan River project. Major portion of the expansion cost will go into the new grinding mill.

Potash Plant: Construction is being pushed ahead on the potash mine of International Minerals and Chemical Corporation (Canada) Ltd., near Esterhazy, Sask.

Investment is estimated at $20 million, with full plant capacity of 400,000 tons annually to be reached in Spring of 1961.

Foundry: A new foundry to cost $110,000 is under construction in Regina, establishing Norwood Foundry (Sask.) Ltd.

Steel Fabricating Plant: Construction was to start in July on the new Regina steel fabricating plant of Dominion Bridge Company Limited.

The $1 million plant is to be the start of a development which will see the company invest some $12 million in the Regina operation over the next 10 years. There will be five stages to the development.

Employment Statistics

The Department of Labour and the Dominion Bureau of Statistics in a joint release in July, reported that employment had reached an all-time record level in June, 1959. An estimated 6,053,000 persons had jobs, 201,000 more than in the previous month, and 174,000 more than the year before. The increase from May to June occurred almost entirely in the non-farm industries, the largest gains being in construction, logging and the distributive industries.

Statistics of Interest

Crude Oil Consumption: Consumption of crude oil in May, 1959 advanced to 20,824,187 barrels, placing January-May consumption nearly 17% over last year, at 108,928,568 barrels.

Carbon Steel: Net shipments of rolled carbon steel products in May rose to 347,763 tons, raising the January-May shipments 13.3% to 1,678,788 tons.

The consuming industries in May were mainly: building construction, 69,026 tons; pipe and tubes, 41,500 merchant trade products, 40,468; railway operating, 40,064; wholesalers and warehouses, 38,914; container industry, 33,163; automotive industries, 18,315; and pressing, forming and stamping, 17,190.

New Steel Wheel Plant

A $12 million fully automated steel wheel plant was opened in June in Montreal, when Canadian Steel Wheel Limited introduced a new industry to Canada.

The plant produces railway steel wheels — with diameter of from 24 in. to 50 in., and weighing up to 2,000 pounds each.

To provide the high-quality steel the melting shop is equipped with two 16-ft. diameter, 45-ton capacity, electric arc melting furnaces. A constant check is kept on the analysis of the steel as it is melted.

The molten metal is poured into a 50-ton capacity ladle and transferred by a 75-ton overhead crane to an ingot pouring car. This car moves the ladle over moulds set in a pit and the metal is teened down centre runners and up into clusters of five or six moulds. The ingots vary in weight from one to three tons. After a regulated period of time, the ingots are stripped from the moulds, transferred to the ingot breaking shop and broken into either three or four blocks. A conveyor system, incorporating scales for weighing the blocks, transfers them either into storage or to the rotary hearth furnace in the wheel forging and rolling shop.

The forging and rolling shop is capable of producing an average of 60 wrought steel wheels an hour, and a feature of the operation is that a permanent record is maintained of the product throughout each stage of manufacture from ingot to finished wheel.

Highly-mechanized handling equipment enables the entire forging and rolling operation to be controlled by only seven operators. The forging and rolling operations, taking only two to three minutes, make it possible to complete the whole cycle in a single heating of the block.

Blocks are heated to forging temperature in a rotary hearth furnace, 60 feet in diameter and capable of heating 40 tons of blocks an hour. In order to control the rate of heating, the furnace is divided into six zones in which temperature and furnace conditions are automatically controlled. The blocks are carried through the heating zones on the rotating hearth until the final zone is reached where the blocks are soaked to forging temperature.

An indicator dial connected to the

• CANADIAN DEVELOPMENTS

hearth shows the number and location of blocks — up to 348 — in the furnace, and a further record is maintained by the operator as part of the product control system. Automatic charging and discharging machines handle blocks in and out of the furnace. The discharging machine swings the blocks through an arc of 90°, passing them through an hydraulic descaler and depositing them on the lower slabbing die of the 6,000-ton forging press.

On the forging press, the block is first reduced to a flat disc between slabbing tools and then transferred by sliding tables to the forming dies. These dies form the hub and part of the web of the wheel, and displace metal to the rim to permit the rolling mill to complete the wheel.

The wheel rolling mill, of the horizontal type, forms the finished profile of the rim of the wheel and in doing so spins metal from the rim into the plate and permits the wheel to grow to the required size. This mill has two edging rolls and a back roll, each driven by separate electric motors and, in addition, two pressure and two guide rolls mounted in separate sliding carriages.

When rolling has been completed, a specially-designed machine removes the wheel from the mill and deposits it on the lower die of the 3,000-ton coning press. This press displaces the hub axially and cones the plate so that the wheel is now formed to its finished profile. All these operations are controlled from specially-designed consoles located in glass-enclosed air conditioned control booths.

After leaving the Forging and Rolling Shop, the wheels are transferred by roller conveyor to the heat treatment furnaces. Three car-type heat treatment furnaces, each nearly 90 ft. long, are fired by light fuel oil and are designed to give flexibility in heat treatment cycles.

University News

University of Toronto

Appointments and promotions in the Faculty of Applied Science and Engineering have been announced by the University of Toronto president, Dr. Claude T. Bissell.

Promoted to professor are: H. S. Ribner, aerophysics; W. F. Graydon, chemical engineering; M. W. Huggins, M.E.I.C., civil engineering; J. M. Ham, electrical engineering; I. W. Smith, mechanical engineering; and S. E. Wolfe, mining engineering.

Promoted to associate professorships are: W. H. Burgess, chemical engineering and A. J. Kravetz, electrical engineering.

Promoted to assistant professor are: F. B. Friend, applied physics and P. E. Burke, electrical engineering. Two newly-appointed assistant professors are: A. R. Straughen, electrical engineering and J. Schwaighofer, civil engineering.

University of New Brunswick

President of the University of New Brunswick, Dr. Colin B. Mackay has announced the appointment of Ira M. Beattie, M.E.I.C., as head of the department of civil engineering and the appointment of Chen-Chang Ting as associate professor of electrical engineering. Mr. Beattie has been acting head of the department since the retirement of Dr. O. E. Turner in 1957.

Assistant professors appointed are: D. A. George, electrical engineering; D. G. Blanchard, civil engineering and Dr. R. B. Banerji; who will lecture for the mathematics department and be in charge of the new digital computer.

INTERNATIONAL NEWS

United Nations

THE WORLD METEOROLOGICAL CONGRESS at its third session in Geneva this year was told that artificial satellites, rockets, balloons and other new devices could play a useful role in helping man learn more about the weather, but could serve most usefully in conjunction with continued normal observations from the surface and upper air.

The Congress is the legislative body of the World Meteorological Organization, a specialized agency of the United Nations with 100 member states and territories and with headquarters in Geneva. It meets once every four years.

The role of satellites was examined by W.M.O. President Andre Viaut (France). The need for international meteorological cooperation was stressed by the president, and the importance of its application to the well-being of mankind, especially to agriculture, aviation, shipping and civil engineering.

A SURVEY OF ENERGY DEVELOPMENT PROBLEMS issued earlier this year by the UN noted that the importance of energy as a basic factor in development is receiving wide recognition. However, it points out, several important aspects of energy development have been neglected, especially as regards economic problems in underdeveloped countries.

The report (Doc. E/3212), prepared by the UN Secretariat at the request of the Economic and Social Council, contains chapters on general energy problems, conventional fuels, non-conventional energy, electric power, and experience and problems in technical assistance. Early action was recommended on the following: appraisal of energy resources, analysis of long-term costs and prices of fuels and power in selected countries; the convening of UN seminars on economic aspects of energy development in underdeveloped countries, in the first instance on the economics of electrification; coordination of the various bodies rendering technical assistance to underdeveloped countries.

The increase in the use of petroleum and the decline of coal trade are mentioned as examples of revolutionary changes in the pattern of international trade. Energy imports are a consideration in most countries, though many are striving for self-sufficiency.

GERMANY

THE RESEARCH INSTITUTE for the Physics of Jet Propulsion in Stuttgart works on basic and applied research in the field of aviation and space travel. This is mainly done by work on the physical, chemical and technological fundamentals of the apparatus of jet propulsion, especially ramjet propulsion, chemical rockets and atomic rockets.

In the field of ramjet propulsion, theoretical work and physical experiments are being carried out as well as technical experiments on carbon hydrate fuelled ramjets.

The theoretical work mainly deals with the thermodynamic states of air and their carbon hydrate combustion gases at high temperatures; and with analytical experiments of thermochemic internal flow (which is done with the help of electronic computors). Other projects are concerned with compiling a technical measurement table for ramjet power plants in the whole field of application up to supersonic flight, into the ionosphere, and on the flight mechanics of ramjet space ships.

Similar experiments on the thermochemic external flow of ramjet power plants and cells serve mainly to ascertain the aerodynamic transformation of heat and the thermal boundaries during stationary flight at great heights.

The physical experiments on ramjets are concerned with molecular rays in the highest possible vacuum in order to get more information of the kinetics of primary chemical combustion and the possible effects of ultra-violet radiation during chemical reactions. Kinetics of reflection of air molecules on different kinds of solid surfaces is being studied also. This is done with special regard to those walls scarcely affected by boundary lays flow and the resulting possible shifting of the thermal boundaries during stationary flight at great heights.

The technical experiments are concerned with the development of smaller ramjet power plants especially for ramjet propellers and ramjet helicopter screws. Larger experiments are planned in the combustion canal, on the sled track, in the air and with supersonic ramjet power plants. The technical aims of these experiments are auxiliary power plants, smallest possible helicopters, and large area aerial defence missiles, as well as supersonic passenger aeroplanes.

In the large field of chemical rockets, theoretical work and experiments are being carried out on the physical and technical side of hot-water rockets. This work mainly deals with analyses of the economical developments of these rockets and drafts, and constructions for the application of hot-water rockets as an economic starting point. The physical experiments on models of hot-water rockets have been carried out in the size two sec./ton power of propulsion and have resulted in very interesting first measurements, e.g. up to 90-95% of usable yield of momentum.

The technical experiments deal with hot-water rockets of more than 200 sec./ton propulsion. The aims are to find special economical rockets with safe start, independent of climatic conditions for unmanned flying objects and manned supersonic aeroplanes.

In the field of atomic rockets extensive theoretical work is being carried out, and physical experiments are in course of preparation. They will deal mainly with production of very hot plasmas and the measurement of their characteristics: convection, radiation, current and heat transmission.

Abstract of News Letter of the Research Institute for the Physics of Jet Propulsion, No. 14.

UNITED STATES-CANADA

NAADC. The Minister of National Defence announces that the President of the United States, with the concurrence of the Canadian Government, has appointed General Laurence S. Kuter to replace General Earle E. Partridge as Commander in Chief, North American Air Defence Command, effective upon the retirement of General Partridge on July 31. Air Marshal C. R. Slemon, R.C.A.F., will continue in the appointment of Deputy Commander, North American Air Defence Command.

UNITED KINGDOM

THE UK STEEL INDUSTRY is described in a booklet issued in January 1959 by the U.K. Information Service.

Although the United Kingdom steel industry today consists of over 300 companies engaged in the manufacture of pig-iron, and in the subsequent processes of making, shaping and treating steel, the bulk of output is concentrated in 25 companies, which between them produce nearly 77% of the pig-iron and nearly 91% of the crude steel manufactured.

World iron ore reserves, it is reported, appear to be adequate for at least 300 years. In 1957, Britain used 32.7 million tons of iron ore, of which 17 million tons were obtained from home ore deposits and the rest imported. The most important iron ore reserves in Britain at present are the Jurassic ores.

To provide for regular and economic shipment of imports of iron ore, special ore-carrying vessels are in service. By 1963 there will be about 72 of these.

In 1957 the consumption of steel scrap amounted to 11.5 million tons, as compared with 12 million tons of pig-iron.

The industry's requirements of coking coal totalled 17.2 million tons in 1957; in addition about 5 million tons of other qualities of coal were consumed. The most important sources of high quality coking coal are the Durham and South Wales coalfields; others are in Lancashire and Scotland. The National Coal Board expects to be able to provide the 24 million tons of coking coal and blended coal, which the steel industry estimates as its annual consumption, by the 1960's.

Major Companies: As the outcome of a series of amalgamations during the last thirty years, the production of steel, though still divided between many often rather small plants, is now concentrated in the hands of some large concerns. Thus in 1952, six firms, operating thirty-two works in which steel was made, each had an output of over one million tons, and an output of 9.5 million tons in the aggregate; that is to say, 58% of total output. A further five firms, operating twelve works, had an aggregate production of over 3 million tons, or an additional 18% of the total. Eleven firms, then, accounted for just over three-quarters of the ingot output. Today, their share is probably even higher, the report states.

The Iron and Steel Board exercises general supervision over the industry. Late in 1958 about five sixths of the iron and steel capacity had been returned to private industry, with one-sixth in the hands of the Iron and Steel Holding and Realization Agency.

Production: Steel production in Britain increased steadily, from 12.7 million tons in 1946 to the record level of 21.7 million ingot tons in 1957. In 1958, mainly as a result of running-down of stocks in the hands of steel users, output dropped to 19.57 million ingot tons. Productive capacity for steel in 1959 is expected to reach 24½ million ingot tons. Blast furnace capacity has also increased greatly since 1945, and pig-iron production totalled 14.3 million tons in 1957, although in the following year output fell back.

In Britain today about 87% of total steel output is made in open hearth furnaces, about 7.5% by the Bessemer converter process and about 5.5% in electric furnaces.

Development plans have been carried out by all British steel companies. There is a development plan for a capacity of 27 million tons in 1962, this program to cost about 650 million up to that year.

U.S.S.R.

AUTOMATION IN A GIANT TIRE FACTORY is to be accomplished by means of a plant performance recorder. The plant, now being built in Russia by a consortium of British firms, will have monitoring equipment by The Digital Engineering Co. Ltd. The entire process of tire and tube making is to be monitored hourly and at the end of each shift, providing a classified summary of output of various components. All the counting equipment will be centralized and an office will be equipped with page printers where the hourly and shift production totals will appear coded according to size or type.

SWEDEN

A TURBINE RESEARCH and model testing laboratory has been put in use by Karlstads Mekaniska Werkstad at their Kristinehamn works, Central Sweden. The laboratory has been designed for all kinds of model tests with pump turbines and includes equipment for precision measurements by means of electronic devices to ensure full objectivity and reliability of the tests.

The new laboratory has three testing units. There is an open flume circuit with 4-metre head for testing complete waterpower plant models with a runner diameter of up to 500 mm. There is a high-pressure cavitation test tunnel especially built for pump turbines but also suitable to be used for tests with models of Francis and Kaplan turbines. The third unit is a cavitation tunnel for Kaplan turbines of conventional type and for testing various types of tubular turbines.

A NEW STARTING UNIT for jet aircraft known as "Air Partner" has been developed and launched on the market by Atlas Copco. The truck-mounted device is of the hot-air type and uses a screw compressor of special design. It is claimed the new unit will reduce the starting time to half, and that it can be operated for 10,000 hours without overhaul.

Month to Month

EIC Annual General Meeting

Minutes of the Annual General Meeting of the Engineering Institute of Canada held in the Concert Hall of the Royal York Hotel, Toronto, Ontario, on June 8, 1959, at 10.00 a.m. until Noon, and presided over by President K. F. Tupper, Toronto.

Notice of Meeting
The General Secretary read the notice of the meeting which had been circulated to the membership on May 1, 1959, with the E.I.C. Annual Report for 1958.

Confirmation of Minutes
There being no amendment or correction to be made, President K. F. Tupper declared the Minutes of the Seventy-Second Annual General Meeting of the Institute held on May 21, 1958, at Quebec City, Quebec, confirmed, and signed the Minute Book.

Nominating Committee For 1959
The General Secretary reported that the Nominating Committee for 1959 has been appointed, one member serving on it from each branch, with Mr. W. K. Gwyer, M.E.I.C. of Trail, B.C. as Chairman.

NOMINATING COMMITTEE 1959

Amherst, R. L. Alexander.
Baie Comeau, T. G. Rust.
Belleville, C. H. Lusk.
Border Cities, C. G. R. Armstrong.
Brockville, R. H. Wallace.
Calgary, A. W. Howard.
Cape Breton, C. N. Murray.
Central British Columbia, E. R. Gayfer.
Chalk River, H. V. Smith.
Corner Brook, K. Bulins.
Cornwall, J. M. Hawkes.
Eastern Townships, J. C. Davidson.
Edmonton, R. N. McManus.
Fredericton, I. M. Beattie.
Halifax, O. N. Mann.
Hamilton, L. C. Sentance.
Huronia, Ross MacKay.
Kingston, D. L. Rigsby.
Kitchener, M. A. Montgomery.
Kootenay, W. G. Small.
Lakehead, E. T. Charnock.
Lethbridge, C. S. Clendening.
London, D. D. C. McGeachy.
Lower St. Lawrence, J. R. Menard.
Moncton, L. R. Wadlyn.
Montreal, C. G. Kingsmill.
Newfoundland, J. P. Henderson.
Niagara Peninsula, C. G. Cline.
Nipissing and Upper Ottawa, T. H. Chapman.
North Eastern Ontario, William Kay.
Northern New Brunswick, R. C. Eddy.
North Nova Scotia, M. C. Wolfe.
North Shore Lower St. Lawrence, M. Storrier.
Ottawa, R. F. Legget.
Peterborough, B. Ottewell.
Port Hope, E. F. Marston.
Prince Edward Island, J. D. M. MacDonald.
Quebec, Paul Vincent.
Saguenay, C. C. Louttit.
Saint John, J. J. Donahue.
St. Maurice Valley, D. M. McKim.
Sarnia, Gordon W. Ames.
Saskatchewan, L. T. Holmes.
Sault Ste. Marie, F. H. MacKay.
Toronto, M. McMurray.
Vancouver, W. O. Scott.
Vancouver Island, Thomas Miard.
Winnipeg, T. E. Storey.
Yukon, J. R. B. Jones.
Chairman: W. K. Gwyer, M.E.I.C., Trail, B.C.

Honours, Prizes and Medals
The President announced that at its meeting held on April 18, 1959, the Council of the Institute voted unanimously that the following Honours, Medals and Prizes be awarded for the year 1959:

HONORARY MEMBERSHIPS
"Chosen from those who have become eminent in engineering or kindred sciences, and elected by unanimous vote of Council".

Randolphe William Diamond, B.A.Sc., D.Sc., recently retired as Director, Consolidated Mining and Smelting Co., Trail, B.C., and also as President of West Kootenay Power and Light Co. Ltd.

David Arnold Keys, B.A., M.A., Ph.D., D.Sc., Scientific Advisor to the President, Atomic Energy of Canada Limited.

Roy Aubrey Spencer, B.Sc., M.Sc., formerly Dean of Engineering, University of Saskatchewan, now Consulting Engineer, Saskatoon, Sask.

John Bertram Stirling, B.Sc., LL.D., President of E. G. M. Cape & Company, Montreal, Que.

James Alfred Vance, President, James A. Vance Company, General Contractors, Woodstock, Ont.

SIR JOHN KENNEDY MEDAL (1958)
"Awarded as a recognition of outstanding merit in the profession or of noteworthy contributions to the science of engineering or to the benefit of the Institute".

Richard Edgar Heartz, B.Sc., LL.D., M.E.I.C., President and Director, The Shawinigan Engineering Company Limited, Montreal, Que.

JULIAN C. SMITH MEDALS (1958)
"For achievement in the development of Canada".

Norris Roy Crump, M.E., D.Eng., D.C.I., LL.D., D.Sc., M.E.I.C., President, Member of Executive Committee and Director, Canadian Pacific Railway, Montreal, Que.

J. Alphonse Ouimet, B.Eng. (Elec.), M.E.I.C., President, The Canadian Broadcasting Corporation, Ottawa, Ontario.

GZOWSKI MEDAL
"For the best paper of the medal year on a civil engineering subject, "Civil" being used in the limited sense to indicate structural surveying and construction work generally".

Raymond Edward Grout, B.Sc., M.E.I.C., Chief Engineer, Electrical Divisision, The Shawinigan Engineering Company Limited, Montreal, Que.

John Arthur Thomas, B.A., B.Sc., M.E.I.C., Chief Engineer, Civil Division, The Shawinigan Engineering Company Limited, Montreal, Que.

For their paper: "Engineering Features of the Beechwood Development".

LEONARD MEDAL
"For papers on mining subjects".

Lazare E. Djingheuzian, M.C.I.M., Senior Engineer, Division of Mineral Dressing and Process Metallurgy, Department of Mines and Technical Surveys, Ottawa, Ont.

For his paper: "A Study of Operating Data from Ball Mines Operating in Quebec, Ontario and Manitoba".

PLUMMER MEDAL
"For papers on chemical and metallurgical subjects".

Robert Owen King, B.A.Sc., M.E.I.C., Defence Research Board, Department of National Defence, Ottawa, Ont.

For his paper: "The Production of Ethylene by the Decomposition of N-Butane; The Prevention of Carbon Formation by the use of Chromium Plating".

DUGGAN MEDAL AND PRIZE
"For the best paper dealing with the use of metals for structural and mechanical purposes".

William Cumming Leith, B.A.Sc., M.A.Sc., Mechanical Research Engineer, Dominion Engineering Works Limited, Montreal, Que.

For his paper: "Cavitation Damage To Metals".

ROSS MEDAL
"For papers on electrical engineering subjects".

Frederic Lewis Lawton, M.E.I.C., Chief Engineer, Power Department, Aluminum Laboratories, Montreal, Que.

For his paper: "Underground Hydro-Electric Power Stations".

ROBERT W. ANGUS MEDAL
"For the best paper on a mechanical engineering subject".

Lawrence Milton Boyd, B.Sc., M.E.I.C., Chief Engineer, Hydraulic Division, Dominion Engineering Works Limited, Lachine, Que.

Walter Scott McIlquham, B.Sc., M.E.I.C., Hydraulic Engineer, Dominion Engineering Works Limited, Lachine, Que.

For their paper: "Beechwood Kaplan Turbines—Hydraulic and Mechanical Features".

H. N. RUTTAN PRIZE (Western Provinces), JOHN GALBRAITH PRIZE (Ontario); Committees recommended no award this year.

ERNEST MARCEAU PRIZE (Quebec—French), PHELPS JOHNSON PRIZE (Quebec—English), MARTIN MURPHY PRIZE (Maritimes); No papers received.

Report of Council for the Year 1958
The General Secretary stated that the Report of Council for 1958 is incorporated in the Annual Report for 1958 which was circulated to the membership as a supplement to the April 1959 issue of **The Engineering Journal.**

Treasurer's Report, Report of Finance Committee, and Financial Statement
The Treasurer, Mr. T. W. Eadie, conveyed the apologies of Mr. Albert Deschamps, Chairman of the Finance Com-

mittee, for his inability to attend the meeting and present the Report of the Finance Committee and Financial Statement. Mr. Eadie stated that the statement of revenues and expenditures and the balance sheet for 1958 is presented in the Annual Report on Page 15, and has been circulated to the membership. It was therefore his intention to merely summarize the results on this occasion, as follows:

"Revenues in 1958 were $27,000 below the 1957 level—a $4,000 increase in membership fees and a $5,000 increase in investment income was offset by a drop of $36,000 in advertising revenues and sales. Expenses on the other hand increased by $54,000 to $595,000. This increase was spread over a number of accounts and, as the Chairman of the Finance Committee states on Page 3 of the Annual Report, reflected among other things an increased activity in the administrative field at both the local and international levels.

"There were no appropriations to building, contingency or publication reserves. There was a draw down from the pension reserve of $2,400. The year's deficit was $32,000 which had to be drawn from surplus, reducing the surplus from $86,000 to $54,000 and the assets from $462,000 to $430,000. A deficit on operations is always a matter of concern and has been receiving the continuing attention of the Finance Committee.

"While our budget for 1959 prepared at the opening of the year contemplated a possible deficit of $10,000 for the year 1959, the actual results to date suggest that a balanced budget may be achieved and you can be assured that the General Secretary and all members of the staff are working assiduously to produce revenues and to control expenses to this end."

Motion for Approval of Report of Council, Report of Finance Committee and Financial Statement, and Treasurer's Report For 1958

It was moved by Mr. J. W. Millar, seconded by Mr. R. Prescott, and carried unanimously, that the Report of Council, The Report of the Finance Committee, The Financial Statement, and the Treasurer's Report for 1958, be accepted and approved.

Committee Reports

The General Secretary reported that the Committee Reports are incorporated in the Annual Report for 1958 on Pages 16 to 23. It was moved by Dr. B. G. Ballard, seconded by Mr. J. S. Waddington, and carried unanimously, that the reports of the following committees be taken as read and approved:

Admissions
Harry F. Bennett Education Fund
Board of Examiners
Canadian Chamber of Commerce
Canadian Standards Association
Confederation
Life Members
Legislation
Papers
Policy
Prairie Water Problems
Professional Interests
Property
Publication
Student Policy
Technical Operations

Branch Reports

The General Secretary reported that the Branch Reports are incorporated in the Annual Report for 1958 on Pages 24 to 39. It was moved by Professor J. B. Mantle, seconded by Colonel W. A. Capelle, and carried unanimously that the reports of the Branches and the Ontario Division be taken as read and approved.

Business from the Annual Council Meeting

The General Secretary reported that no business had been referred specifically from the Annual Council meeting held on June 7, 1959, to the Annual General Meeting.

Confederation

The President stated that Council's report on Confederation is printed on Page 6 of the Annual Report for 1958. He invited Mr. T. Foulkes, Ottawa, Acting Chairman of the E.I.C. Committee on Confederation, to report to the Annual General Meeting in the absence of Dr. I. R. Tait, Chairman. Mr. Foulkes thanked the President for this opportunity to address the membership on the subject of the work of the Committees on Confederation, and reminded those present that a report of the E.I.C. Committees activities is presented on Page 18 of the Annual Report for 1958. Mr. Foulkes reported that the Council of the Institute at its meeting held in April 1959 approved the joint report of the E.I.C. and C.C.P.E. Committees on Confederation, dated March 18, 1959. At the same meeting, Council gave authority to the E.I.C. Committee on Confederation to instruct the General Secretary to proceed with mailing a ballot on the principle of Confederation at an appropriate time to fully pail-up corporate members. At the Annual Meeting of the Canadian Council of Professional Engineers held in Winnipeg on May 20 to 22, 1959, the members of that body also accepted the joint report, on the understanding that it would ask its constituent bodies to appoint members to the proposed Engineers' Confederation Commission (previously called a Provisional Council) and stipulated that its approval did not bind it to accepting the report of this Commission, but that this report should be submitted to the C.C.P.E. again for approval. On receiving advice of this action, the E.I.C. Committee on Confederation consulted with the President and requested the General Secretary and his staff to proceed with mailing the ballot to fully paid-up corporate members of the Institute.

This was done on June 4, 1959: the package consisted of a letter from the President of the Institute, the joint report of the E.I.C. and C.C.P.E. Committees on Confederation dated March 18, 1959, ballot paper, ballot envelope and return envelope. In anticipation of a favourable ballot from the membership, Council agreed at its Annual Meeting held on Sunday, June 7, 1959, that it would take preliminary steps towards the appointment of E.I.C. members to the Engineers' Confederation Commission. Mr. Foulkes emphasized that some members of the E.I.C. Committee on Confederation were present at the Annual Meeting and would be pleased to answer any questions or listen to suggestions which might be directed towards them. He said they would endeavour to give answers to the questions in the light of present documents, and to illustrate the spirit behind the documents. This was the first time that it had been possible to release copies of the joint report to the membership, and the Institute members are now being asked to vote on the report and to say whether or not they are in favour of the principle of Confederation as outlined in the report. The Committee felt it necessary to have a mandate from the membership on the principle of Confederation before undertaking the great amount of work necessary to draw up a final report and detailed plan of the organization. He therefore urged the membership to vote as they wished, but vote. This will enable the E.I.C. to continue negotiations with the C.C.P.E. in drawing up final documents for submission to the membership of the respective bodies.

The President thanked Mr. Foulkes for his report and informed those present that the subject of Confederation has been much discussed by Council throughout the year. Unfortunately, the Annual General Meeting is the only occasion each year when the membership as a whole can discuss it with Councillors and the members of the Confederation Committee. He therefore urged that there be a full discussion on the subject.

Past-President L. F. Grant, Kingston, stated that throughout these proceedings he had noticed a great deal of ignorance on the subject of Confederation. As Mr. Foulkes had said, this was the first opportunity that the general membership had had of seeing the proposals for Confederation. It was true that progress reports had been published in **The Engineering Journal** from time to time, and to that extent the members should know what was going on. Although this ballot commits the Institute only to the general principles of Confederation, there are certain aspects of it that are causing deep concern. One of these—and it might as well be faced—is the elimination of the branches. There is no provision for branches in the report: there is no provision for the money to operate the branches, and he wondered if at the Branch Officers' Conference, held the previous day, they had considered ways and means of operating branches without money from Headquarters. There had been a hope expressed that something would be done to enable the branches to continue, but it is very different from the system which has been sustained in the past. It had been repeatedly said "leave these things alone, they will all be ironed out". He submitted that it was too important a question to be left to the bare possibility of it being "ironed out".

Colonel Grant said that a similar though not identical question, is the lack of contact of the individual member with the new body. In the past a member has had this through a councillor at his branch. True that many councillors did not attend meetings, especially those for whom access was difficult. There were nonetheless very few branches that, at some time or another, had not sent a councillor to attend a meeting when a question of particular importance to them was to be discussed. He did not know what was the state of the other Associations, but in Ontario he had seen no machinery for the individual member to approach Council. He did not suppose that if a member did, his approach would be thrown into the waste basket, but the machinery to which the E.I.C. membership is accustomed does not exist there.

Colonel Grant expressed concern that the Canadian Council of Professional Engineers was not sending out a ballot on the principle of Confederation and that the E.I.C. was therefore "out of step" by doing so. It had always been a principle of the two committees that the two negotiative bodies should march in step but he did not think that this was now the case.

There were several proposals in the report which he did not like: he thought the tendency was towards centralization and domination by Headquarters. There are only two vice-presidents, and the number of councillors is much smaller. He did not intend to go into details but he trusted that branches would hold meetings on the report prior to voting, and that at that time they would consider the important points which he had raised—the most vital one being the apparent elimination of the branches. (Applause).

Mr. Leo E. Roy, Montreal, a member of the E.I.C. Committee on Confederation, said that he fully agreed with Colonel Grant's view regarding the importance of branches in the new Confederation. He believed that the members of the E.I.C. Committee on Confederation had investigated the matter very seriously and that there are many difficulties yet to be solved. He drew the meeting's attention to Clause 5 which he read together with the explanation of this clause. He thought this proved that the committee is aware of the situation regarding branches and urged that it be borne in mind that at present the vote is merely on the principle of Confederation. He was confident that the Engineers' Confederation Commission would be able to work out the problem of satisfying all members of the new organization if that meant having branches (Applause).

Mr. W. L. Hutchison, Toronto, said he wished to make one observation, namely, that as an ordinary member of the Institute he had found it exceedingly difficult in the past to keep informed on the work of the committee, which he was sure had worked assiduously. The points enumerated by Colonel Grant concerned him also, and he had several questions on the report. His greatest concern was the fact that members of the Institute had not had the opportunity to know some of the details behind the report and, as a result of this, might vote "No" and, in his estimation, reject something which should be considered seriously. He said that if the report were rejected at this stage, it will not be possible to resume Confederation negotiations for many years. He urged that, although it is too late to do anything about the present situation, the membership be kept better informed from now onwards of the activities of the Engineers' Confederation Commission, if it is appointed, so that if and when a final vote is taken on Confederation, the membership is fully aware

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of what it is voting for. (Applause). Past-President J. B. Challies, Montreal, said he was against the whole proposal: he thought that the membership would find that the majority of the Past-Presidents are against it also. They felt that the representatives of the Institute on the joint committee had "swallowed the bait" of those who are so actively interested in Confederation, "hook, line, and sinker". There was no doubt about the fact that if Confederation goes through as it is set up now, the E.I.C. becomes a captive organization of the Provincial Associations. He asked what was being gained by it. When he was President of the E.I.C. twenty years ago there was one thing that he had learned, namely, that the members of the E.I.C. hoped that some day there would be a common membership between the Institute and the Associations but on a basis fair to the E.I.C. and not on the basis at present proposed. In his opinion the ballot which had been sent to the membership was irregular and illegal. It was received the day before the Annual General Meeting. The By-Laws state that the Council must be informed of any proposed change by October 1st and the membership twenty-one days prior to the Annual General Meeting. He asked whether there could be a more important change than the one envisaged by Confederation. He emphasized that there would no longer be an independent E.I.C.; instead it would be dominated by the Associations. He reminded the meeting that the Institute had helped with the formation of the Associations because the members of the Institute were almost unanimously in favour of a registration movement. He again emphasized that the Institute By-Laws require that any contemplated change or addition to them must be discussed both at an Annual General Meeting and by each of the Branches, and must be approved by Council. When a ballot goes out to the membership, it must be accompanied by a clear memorandum stating the arguments for and against the proposed change. The confederation report accompanying the present ballot was, he considered, the most complicated document he had ever seen.

Dr. Challies said that he did not like the idea of Confederation. Colonel Grant had made a very important point, namely, "what about the branches"? He asked whether the E.I.C. was just going to let the Associations say whether or not the Montreal Branch and the Toronto Branch, for example, could exist in the future. He considered that the whole scheme was "cockeyed" and he could not understand how it had come about—unless it had come about under cover. Dr. Challies said he had no wish to stand in the way of progress, but he did want this progress to be on a fair basis for the E.I.C. and on a basis that is worked out by the E.I.C. membership in accordance with the E.I.C. By-Laws. He understood that, generally speaking, at the most 45% of the members vote when a ballot is sent round. As the present ballot is to be decided by a simple majority, he did not consider that the vote would be representative of the Institute's membership. He understood that the membership of only one Association had voted on the report or would do so at this stage. He had quarrelled with Irving Tait on this issue and Dr. Tait had said "In one or two cases the provincial registration bodies would turn it down." Dr. Challies said that he did not want to sit by and wait for their decision: this was no answer to the problem.

He contended that the E.I.C. is dependent on its branches and that when the branches begin to realize what is going to happen under a new organization, they will not accept the Confederation proposal.

Dr. Challies said that although he was not in good health, he had made up his mind that if it was the last thing he did for the Institute, he would be present at this Annual General Meeting to warn the membership not to vote for this proposal. He asked if those present could imagine the Canadian Parliament being composed of representatives from the various Provincial legislatures. He was confident that many E.I.C. members did not understand the full implication of this proposal to the future of the E.I.C. In closing his remarks, Dr. Challies paid deep tribute to the gentlemen who have negotiated on the problem of Confederation. Although he was very much against the proposal, he appreciated the fact that those carrying out the negotiations on behalf of both bodies had worked extremely hard.

The President said he would like to try and assure Dr. Challies that, in his opinion, although he could be wrong, he did not think the present ballot was illegal for the reasons Dr. Challies had set forth. Dr. Challies replied that its legality might well be contested in court. The President emphasized that the present Confederation ballot did not promulgate anything. He regarded it merely as a vote which, if favourable, would permit another step of exploration to be begun.

In reply to some of the queries raised, Mr. Foulkes drew the attention of those present to Pages 10 and 12 of the joint report. Part "D" of Page 10 outlines the procedures to be followed by the Canadian Council of Professional Engineers. It will be noted that there is no provision in that procedure to submit the matter to the members of the Associations before appointing the C.C.P.E. members to the Engineers' Confederation Commission. On Page 12, Part "E" of the joint report, it is to be noted that the E.I.C. Committee on Confederation insisted in Item 2 that a report and ballot be submitted to the membership of the Institute, thereby preserving the democratic quality of its organization. The E.I.C. Committee members did not think it fair to ask permission to proceed with the details of trying to consummate the Confederation or joint body of engineers if the members of one constituent body were not in favour of the principle involved.

Mr. Foulkes said that there has been no secret about the proposal for Confederation. He emphasized this by reading extracts from the minutes of the 72nd Annual General Meeting of the Institute, concerning Confederation.

Mr. Foulkes stated that the clauses contained in the minutes of the special meeting of the Council held in Quebec City in May, 1958, had remained unchanged except for Clause 8 where the figure for fees had been altered from Six Dollars to Six Dollars and Twenty-Five Cents. He said the clauses had been published and had been available for a whole year for anyone on the membership to read and to ask questions about. The Institute had paid the expenses for councillors to attend two special meetings regarding Confederation — one held in Quebec City in May, 1958, and one in Toronto in January, 1959. In both cases a full report on the proposals regarding Confederation was either appended to or contained in the minutes. In addition the joint report of the Committees on Confederation, dated March 18, 1959, was discussed at the April meeting of the Council of the Institute, and a copy of it was appended to the minutes which were sent to councillors and branch chairman throughout the country. The officers therefore had every opportunity to present it to their executives and branch members, and to discuss it with them. He contended that the Institute is a democratic organization under its present method of representation, and that information regarding Confederation proposals had been passed on and made available to the membership. He admitted that when the ballot was mailed to the membership on June 4 it was the first time that a report on Confederation had been put in the mailbox of each individual member eligible to receive it. No change to the report had been made in the last twelve months. From Page 7 onwards the report comprised an attempt on the part of the E.I.C. Committee to interpret the clauses, and in this work the Committee had received a great deal of help from the General Consultant.

He informed the meeting that the E.I.C. representatives on the joint Committee on Confederation had received great cooperation from the representatives of the C.C.P.E., all of whom are also members of the Institute. He said there had been a spirit of "give and take" and that none of the policy had been dictated by paid servants of the professional bodies. He wished the meeting to know that, with the exception of the Institute's former General Secretary, there were no paid staff of the Associations, the Corporation or the Institute present at any of the joint meetings.

Mr. Foulkes agreed that the question of branches was one which required further negotiation and caused the E.I.C. Committee a great deal of concern. He stated that the Committee had been acting as the Institute's representative and on occasion asked Council for guidance. At the Annual Meeting of Council on June 7, 1959, they asked for ideas to improve proposed arrangements for branch operation under the new organization. The proposal regarding branch financing was the best that the Joint Committee had been able to agree upon so far. If this Annual General Meeting required something stronger than the proposal as it now stood, it was perfectly at liberty to inform the E.I.C. members on the Engineers' Confederation Commission of its wishes in this matter.

Mr. Foulkes explained that the Council members of the new organization would have the rank of a President or Vice-President of the Institute. For example, in Ontario where there is the greatest number of branches, some system of regional communication would be set up which would make it mandatory to keep in touch with the representatives of the branches. There was no reason why there should not be some regional councils. The business of running a national organization is not new — service clubs accomplish it and surely engineers can work out a suitable method of representation. The last thought that existed in the minds of those who had prepared the joint report was that the branches of the national body of engineers should be eliminated.

In answering Mr. Hutchison's question, Mr. Foulkes admitted that there may have been some lack of publicity. The reason had been that the E.I.C. and the C.C.P.E. were anxious to keep in step with one another. This was not possible if one body released a report on Confederation which might be embarrassing to the other; in the initial stages of negotiation it had been necessary to curb publicity until agreement had been reached. He thought it possible that publicity regarding any future negotiations may lapse into a period of quiet. He was of the opinion that the activities of the Engineers' Confederation Commission should be reported at every meeting of Council and releases on the status of negotiations be made in **The Engineering Journal**. (Applause).

Mr. F. A. Brown, Past-Chairman of the Saguenay Branch, said he would like to thank the members of the E.I.C. Committee on Confederation for their excellent work. He said they are all very busy men who have given up much of their time and he did not think the Institute could be better represented on the Joint Committee on Confederation. As a past-chairman of a Branch he liked the thought that the branches themselves would say whether or not they were going to exist under the new organization. They could not be legislated out of existence. If the agreement did not contain financial provision for them the branches will have to work out a system for themselves. He would like to see a strong national body, and that he had every confidence in the present Joint Committee on Confederation.

Professor C. G. E. Downing, Guelph, said that it appeared that the new national body would consist of members of the E.I.C. and the Associations and Corporation. He inquired about the status of engineers in the CIC, CIMM, or other Canadian engineering groups. It appeared that the membership in the new organization was mandatory, and he inquired what was envisaged for "associate members" such as are now supporting the E.I.C. but who are not members of an Association.

Mr. Foulkes recalled that when Mr. Herbert Smith evolved his "Plan for Unity" he had hoped that the CIC, CIMM, and other engineering groups would join with the CCPE and the E.I.C. in the formation of a national body of engineers. The CIC and CIMM said that only a portion of their membership were capable of being registered as professional engineers and that they would rather not enter into negotiation. If any members of their organizations were registered with the Association or enrolled in the E.I.C., under the proposed new plan they would automatically be members of the

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new national body. Adequate provision has been made for "associate" or "affiliate" members and an explanation is given on Page 8 of the report, Clause 2. Mr. J. R. Rattie, Winnipeg, inquired how long it would be before Confederation took place. Mr. Foulkes replied that the proposal laid down that the Commission would be appointed for one year and provision was also made to extend its activities for a further year. There had been no definite date set for the completion of negotiations and Mr. Foulkes thought that if a favourable report and ballot were received the earliest date for Confederation would be 1961. Judging from the time it took to reach the present stage in negotiations he did not think that Confederation could be accomplished within one year. Mr. Rettie said that if this were the case the Winnipeg Branch was looking forward to being host at the Annual Meeting of the E.I.C. scheduled to be held in Winnipeg from May 25-27, 1960.

Mr. R. A. McGeachy, Sarnia, said that he had attended many Council meetings and he would like to stress that the gentlemen who have been negotiating on behalf of the E.I.C. are extremely honorable, that the whole joint committee is working for the best interest of engineers in Canada, and that there is no question of one body trying to undermine the other.

Professor L. E. Gads from Alberta said he presumed when he reached home after attending the Annual Meeting that he would receive his ballot in the mail and that he would mark it "yes" and mail it back to Headquarters. He said that he had been a member of the Edmonton Branch for about twenty years as well as a member of the Provincial Association, and he believed that he could be termed as "an ordinary rank and file member". He attended as many meetings of both the Association and the Institute as he could, and he had also attended Annual Meetings of the Institute and the Provincial Association, and believed that he had a reasonable understanding of the affairs of both organizations. He belonged to the 45% group that answers and returns ballots when they are sent out, and resented the implication that he, as an average member, was going to be so innocent as to be "led down the garden path" and assist in the dissolution of the E.I.C. just because he is not a member of the E.I.C. Council. He also resented the implication that the members elected to office had perpetrated something for which the membership would be sorry. He remembered the question of "unity" being discussed many years ago and even at that time some people almost came to blows on the question. He could see the implications of the proposal clearly enough to mark his ballot paper "yes" and he hoped this would give the Engineers' Confederation Commission an opportunity to work out details for a new organization and to present a clear picture of its plans to the membership in the future. (Applause).

Mr. R. F. Legget, Ottawa, stated that if the new Engineers' Confederation Commission were appointed when the result of the ballot was known, this Annual General Meeting might be the last one to which the E.I.C. Committee on Confederation was asked to report. Councillors knew that there had been few committees of the Institute which had devoted so much attention to the Institute's affairs. He considered it would be inappropriate to allow the meeting to close without moving a vote of thanks to the E.I.C. Committee on Confederation, under the chairmanship of Dr. I. R. Tait, for the splendid job they have done in the interests of the engineering profession of Canada. The motion was seconded by Past-President McKillop and carried by acclamation.

Report on Election of Officers

The President reported that a new President, three new Vice-Presidents representing Quebec, Ontario and the Western Provinces, and an appropriate number of councillors had been elected at the December 1958 meeting of Council in accordance with the By-Laws. These would be formally introduced at the Annual Banquet. He introduced to the meeting Mr. J. J. Hanna, Calgary, Alberta, the Institute's new President for 1959.

PRESIDENT

J. J. Hanna, Calgary, Alberta

VICE-PRESIDENTS

Zone A (Western Provinces)
C. V. Antenbring, Winnipeg, Man.

Zone B (Province of Ontario)
R. B. Chandler, Port Arthur, Ont.

Zone C (Province of Quebec)
F. L. Lawton, Montreal, Que.

COUNCILLORS

Yukon, N. Gritzuk, (Whitehorse)
Vancouver Island, P. F. Fairfull, (Victoria)
Vancouver, P. N. Bland
Central British Columbia, H. R. Hatfield, (Penticton, B.C.)
Kootenay, A. F. Brooks, (Trail, B.C.)
Edmonton, T. H. Newton
Saskatchewan, A. H. Douglas, (Saskatoon)
Winnipeg, Stewart Barkwell
Lakehead, D. B. McKillop, (Fort William)
Sudbury, F. A. Orange, (Copper Cliff)
London, A. L. Furanna
Port Hope, H. A. Gadd, (Cobourg, Ont.)
Kingston, J. W. Dolphin
Nipissing and Upper Ottawa, J. W. Millar, (North Bay)
Toronto, R. Harvey Self
Belleville, A. D. Janitsch
Brockville, J. S. Waddington
Chalk River, C. A. Crawford
Ottawa, Hector Chaput
Montreal, T. N. Davidson, P. W. Gooch, Jacques Hurtubise
Eastern Townships, A. S. Mitchell, (Lennoxville)
St. Maurice Valley, Viggo Jepsen, (Grand'Mere)
North Shore Lower St. Lawrence, B. M. Monaghan, (Seven Islands)
Lower St. Lawrence, Jean R. Menard, (Rimouski)
Saguenay, A. B. Sinclair, (Kenogami)
Baie Comeau, Charles Miller
Fredericton, S. B. Cassidy
Saint John, T. C. Higginson
Halifax, R. D. T. Wickwire
Prince Edward Island, N. F. Stewart, (Charlottetown)
Amherst, Lawrence L. Spurr, (Sackville)
Corner Brook, M. C. Collins
Newfoundland, C. H. Conroy, (St. John's)
Border Cities, W. G. Mitchell, (Walkerville)

Vote of Thanks

It was moved by Past-President L. F. Grant, seconded by Past-President Ross L. Dobbin, and carried by acclamation that a very hearty vote of thanks be accorded to the retiring President and Members of Council in appreciation for the work that they have done for the Institute during the past year. The President said that he would like to transmit this vote of thanks to the 1958 Councillors of the Institute. He stated that many of them have attended meetings at considerable personal inconvenience and that he appreciated the work undertaken by the individual Members of Council during the past year.

Mr. F. L. Lawton stated that, having on many occasions worked very closely with them, he would not like to let this opportunity pass without expressing his own appreciation, and he hoped the appreciation of the members, for the courtesy, efficiency, promptness, and co-operation of the General Secretary, Dr. Garnet T. Page, and his staff at E.I.C. Headquarters. (Applause). The President said he hoped that Dr. Page and members of the staff present at the meeting would take note of this sentiment and instructed them to convey it to the members of the staff not present.

Motion For Adjournment

It was moved by Mr. R. A. McGeachy, seconded by Mr. J. H. Budden, and carried unanimously that the 73rd Annual General Meeting of The Engineering Institute of Canada be adjourned.

The meeting adjourned at 12.00 Noon.

President: K. F. Tupper
General Secretary: Garnet T. Page
The Engineering Institute of Canada,
2050 Mansfield Street,
Montreal, Que.
July 22, 1959.

NATIONAL CONFERENCE ON PROFESSIONAL DEVELOPMENT PROGRAMS

Over forty delegates from across Canada attended the first national conference on Professional Development Programs June 9 at the Royal York Hotel in Toronto. The forum, held at the same time as the E.I.C.'s annual meeting, was a milestone in the efforts of young engineers to broaden their interest in non-technical subjects.

The newly formed National Committee on Professional Developments Programs undertook the organization of this conference as the first of their projects to bring together representatives of the twelve PD Programs in Canada and to interest those local branches which are not running programs in their work.

Set up in April, 1959, by the E.I.C. Council to assist local branches, the committee is chaired by Councillor E. T. W. Bailey, of Hamilton, and consists of a corresponding secretary from each branch and a small executive drawn at present from past members of the Hamilton, Niagara, and Toronto Program Directorates.

Delegates to the conference were welcomed by Dr. K. F. Tupper and Dr. Page. Dean C. Wandmacher of the Engineers' Council for Professional Development, which represents eight engineering societies in the U.S.A. and Canada, outlined activities going on in the U.S.A. in professional development. Doctor Tupper and Dean Wandmacher both paid tribute to the work of Col. L. F. Grant in starting the PD Programs in Canada as former president of the E.C.P.D.

Reports from twelve PD Programs across Canada showed enrolments ranging from 30 to 336. Program contents ranged from four-year integrated courses covering many fields (public speaking, the art of listening, business administration and finance) to detailed courses on single subjects such as law and economics. Some branches organize courses with little outside help; others work closely with local universities.

Address by Dean Mordell, McGill

Dean Mordell of McGill University opened the afternoon session, describing three essential requirements for a successful professional engineer — technical ability, the power to analyse a problem and to apply sound scientific principles to a wide range of technical problems; an appreciation of the broad view and an open mind to gain new knowledge; the ability to understand and communicate with other people, giving leadership when necessary. The university can only open an engineer's mind, not complete his education, Dean Mordell pointed out.

The university, the individual, and the profession all play a part in making the professional engineer, according to the dean. The profession is a community and the members owe it to the

(*Continued on page 118*)

Presentation of

Honours and Awards

at Toronto, 1959

Honourary Memberships

Randolphe William Diamond, Trail, B.C.
David Arnold Keys, Deep River, Ont.
John Bertram Stirling, Montreal, Que.




Julian C. Smith Medals

Norris Roy Crump, M.E.I.C., Montreal, Que.
J. Alphonse Ouimet, M.E.I.C., Ottawa, Ont.
(*accepted on his behalf by J. E. Hayes,* M.E.I.C.)

Gzowski Medal

Raymond Edward Grout, Montreal, Que.
John Arthur Thomas, Montreal, Que.



Robert W. Angus Medal

Lawrence Milton Boyd, M.E.I.C., Montreal, Que.
Walter Scott McIlquham, M.E.I.C., Montreal, Que.

Sir John Kennedy Medal

Richard Edgar Heartz, M.E.I.C., Montreal, Que.

Leonard Medal

Lazar Eruant Djingheuzian, Ottawa, Ont.

Plummer Medal

Robert Owen King, M.E.I.C., Ottawa, Ont.

Duggan Medal and Prize

William Cumming Leith, Montreal, Que.

Ross Medal

Frederic Lewis Lawton, M.E.I.C., Montreal, Que.

FIRST TIME IN OTTAWA

OTTAWA REGIONAL

THURSDAY & FRIDAY

CHATEAU LAURIER

REGISTRATION • by special form as mailed to each member or by writing the treasurer of the Ottawa Branch, 2039, Prince Charles Road or during conference at the lounge facilities.

ACCOMMODATION • at the Chateau Laurier Hotel by the special form mailed to each member.

TECHNICAL PROGRAM • see details on opposite page.

TECHNICAL DISPLAY • Atomic Energy Display and photographic panorama of Ottawa district engineering achievements.

LUNCHEONS • two luncheon meetings featuring outstanding speakers, in the Ballroom. See details.

LADIES' PROGRAM • a special tour on Thursday afternoon and coffee party on Friday morning have been arranged by the Engineers' Wives Association.

RECEPTION • in the Drawing room for one hour prior to the dinner.

DINNER DANCE • dinner in the Ballroom from 7.30 to 9.30 p.m. The president, Mr. Hanna, will speak. From 9.30 to 12.30 p.m. the dance will be in full swing (informal dress).

THE ENGINEERING INSTITUTE

TECHNICAL CONFERENCE

OCTOBER 15 & 16 1959

OTTAWA CANADA

EIC **TECHNICAL PROGRAM**

THURSDAY, OCTOBER 15

10:00 INTRODUCTION AND WELCOME

10:30 The Development of Fuel for NRU A. J. Mooradian, *Superintendent, Applied Engineering Development Branch, AEC.*

11:15 Atomic Reactor Research Operations D. G. Breckon, *Superintendent, NRX Reactor Branch, AEC.*

12:30 LUNCHEON. Mr. Winnett Boyd will speak on "The Nuclear Future of Canada — The Promise and the Prospects."

2:00 The Development of Fuel Cells and Thermo-electric Devices R. R. Jackson & E. L. R. Webb, *N.R.C.*

2:45 Application of Electronic Devices to Geophysical Surveying L. W. Morley, *Dept. of Mines and Technical Surveys.*

3:30 Design of Paper Machine Drives W. Messervey, *C.G.E.*

4:15 Remote Control of Dufferin Falls Generating Station W. S. Watson & V. Gabruss, *Shawinigan Engineering Co. Ltd.*

FRIDAY, OCTOBER 16

9:15 Engineering and Early Ottawa R. F. Legget, *N.R.C.*

10:00 The Design of the Ottawa Sewage Treatment Plant J. W. MacLaren, N. D. Pappas & D. B. Clement *James F. MacLaren Associates.*

10:45 Alignment Design of Highway Interchanges W. J. Malone of *De Leuw Cather & Co. of Canada Limited.*

11:30 Subsurface Investigation for the Ottawa Sewer Tunnel G. C. McRostie, *McRostie and Associates.*

12.30 LUNCHEON. Dr. John Convey will speak on "Mining and Metallurgy in the Ottawa Valley."

2:00 Development of the Hilton Mine at Shawville H. C. Gerber, *General Superintendent.*

Pit Operation at the Hilton Mine W. J. Riddell.

Mill Operation at the Hilton Mine H. Halupka.

3:45 Winter Construction in Ottawa C. R. Crocker, *N.R.C.*

OF CANADA

CHATEAU LAURIER

NATIONAL CONFERENCE ON PROFESSIONAL DEVELOPMENT PROGRAMS

(Continued from page 114)

community to help those aspirants who are prepared to work hard to join the ranks of the profession. Giving a young man his iron ring at the ceremony of the calling of an engineer, welcoming him and then forgetting him, is not enough. It is an encouraging sign that many branches are organizing professional development programs to help the young engineer in this difficult transition from university to becoming a full-fledged member of the profession.

Dr. Lillian Gilbreth, world-famous engineer and author, made an appearance at the conference unexpectedly, and expressed her support for this type of program with its emphasis on the lifelong education of the engineer.

Discussion Groups

The luncheon table discussion groups brought up a variety of interesting questions concerning Professional Development Programs. Among them:

"A PDP course was not organized by our branch because of the diversity of opinions regarding the kind of course and subject matter." *Discussion:* It may be that what engineers want is the chance to discuss and think together on a variety of subjects to learn to express themselves. If this is so, the choice of subject matter is only of secondary importance.

"It was felt that there are sufficient night schools and colleges available to members, therefore we do not need a PDP " *Discussion:* In many places these courses are not available. Also, as Dean Mordell indicated, night schools and technical courses provide technological instruction rather than the broader training.

"There is a lack of junior members in the area." *Discussion:* More attention should be focussed upon getting employers to recognize the value of PDP. A certificate could be given to engineers completing the course. There could be more co-ordination with the local E.I.C. branch and more contact with upper levels of managers and employers.

"These various organizations offer similar courses to those offered by the universities."

Discussion: There are four main differences. The PDP offers much greater scope for participation. The PDP courses are broader and designed to awaken interest rather than to give complete knowledge. They are designed specifically to give courses in non-technical subjects to engineers. Fourthly, PDP can probably run courses more cheaply than can a university.

NEWS OF THE

Associations and Corporation

Information received through co-operation of the provincial organizations.

Canadian Council

The Annual Meeting

Report abstracted from "The Professional Engineer", July, 1959.

The 22nd annual meeting of Canadian Council was undoubtedly one of the busiest and most productive meetings ever held by this organization. A record number of twenty-one formal reports were considered and many important decisions were taken. An unprecedented spirit of true co-operation was in evidence throughout the proceedings and the genial hospitality of the Manitoba Association contributed in considerable measure to the success of the meeting.

Most of the important problems concerning the profession were discussed and some of these are reported elsewhere in this issue. Other matters dealt with included the following.

Ethics—After two years of study, the committee submitted its final report and the proposed uniform Code of Ethics has been referred to the Associations and Corporation for consideration and study.

Federal Legislation—A report on current federal legislation was tabled and in order that Council be in a position to take action quickly if required, in connection with proposed new legislation, the Executive Committee was authorized to appoint a committee to deal with legislative matters at Federal Government level.

Salaries—The method of dealing with the question of engineers' salaries was fully discussed and the representatives from British Columbia reported that their Association, in the interest of uniformity, was now prepared to endorse the annual Report on Salaries of Professional Engineers by Levels of Responsibility as published by Canadian Council in 1958. It was therefore agreed that a new Report be published in 1959 with the seal of approval of all eleven Associations. It was unanimously agreed to continue the annual salary survey.

Amendments to Constitution—A number of amendments to the Constitution of the Council which were considered to be urgent to improve the efficiency of the organization and to regularize current practices were approved. These include the addition of a President who will not represent an association, to the existing eleven members of the Council, the President having the right to vote only when the votes of the members are equally divided; a new definition of the duties and responsibilities of the Secretary who will now use the title of Executive Secretary; an increase in the maximum assessment to $1.50 per member; the creation of an Executive Committee whose powers are determined by the Council; and a few other amendments of a minor nature.

Model Law—It was unanimously agreed that a committee be formed to prepare a Recommended Uniform Professional Engineer's Act for the assistance and guidance of the associations. This proposed Model Act is intended to serve as a guide with a view to attaining a uniform high standard throughout Canada.

Fees—A committee will be appointed to study the question of fees and consulting practice on a national basis. It is hoped that this step will assist in obtaining adequate and uniform schedules of fees and high standards of consulting practice in all provinces.

Engineers & Unions—The question of engineers and labour unions received considerable attention. Some associations would make it unethical for their members to voluntarily join labour unions while others feel that other methods should be used, such as assisting engineers employed in large organizations in making collective representations to management. Although all delegates agreed that it is highly desirable to keep professional engineers out of labour unions, no formal decision was taken.

Engineering Technicians—Several Associations reported considerable interest in this problem and a detailed report of the activities of the Ontario Association in this field was presented.

Counselling in Engineering—A detailed report of the activities of the various associations in this field was submitted by the Secretary-Treasurer.

Syllabus of Examinations—After years of study, the Committee on Revision of the Uniform Syllabus of Examinations submitted a report recommending substantial revisions to the Syllabus which is presently in use in all provinces.

Tariff Item 180e—A committee was appointed to investigate and study the problem of tariffs on the importation of engineering plans, drawings and specifications and to recommend to this Council any action that may be deemed advisable in the best interest of the Canadian economy and of our profession.

Council Officers Elected

Officers of Canadian Council for 1959-60, elected at the Winnipeg meeting were:

President: Donald O. Turnbull, P.Eng., Past-President of the Association of Professional Engineers of New Brunswick. Mr. Turnbull is engaged in consulting practice in St. John, New Brunswick.

Viçe-President: J. G. Dale, P.Eng., Past-President of the Association of Professional Engineers of Alberta. Mr. Dale is Manager of Customer Service & Utilization, Northwestern Utilities Ltd. in Edmonton, Alberta.

Executive member: W. L. Wardrop, P.Eng., President of the Association of Professional Engineers of Manitoba. Mr. Wardrop is engaged in consulting practice in Winnipeg, Manitoba.

Secretary-Treasurer: Leopold M. Nadeau, P.Eng., of Ottawa.

Canadian Council Office

Permanent office of the Canadian Council is now established at 77 Metcalfe St., Ottawa, in charge of Leopold M. Nadeau, executive secretary.

Personals

B. F. Lamson, M.E.I.C. (Queen's '12) of Proctor & Redfern, Consulting Engineers, Toronto, has been appointed special representative for the company's Niagara Peninsula area.

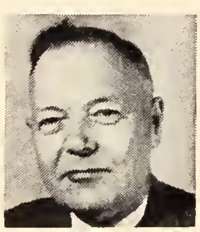

B. F. Lamson, M.E.I.C.


Ervin B. Parrag, M.E.I.C.

Ervin B. Parrag, M.E.I.C. (Budapest '26) well-known engineer has opened his own engineering consulting service in Montreal to be known as Ervin B. Parrag and Associates.

Douglas F. Hamelin, M.E.I.C. (California '29) has been transferred by Western Water Wells & Hamelin Drilling Ltd., Calgary, to the company's branch in Vancouver, where he will be manager of B.C. operations.


Douglas F. Hamelin, M.E.I.C.


J. Stuart Neil, M.E.I.C.

J. Stuart Neil, M.E.I.C. (Alberta '30) construction engineer with McColl Frontenac Oil, Calgary, has been elected chairman of the Calgary branch of the Institute.

Robert S. Stockton, M.E.I.C. (Colorado '95) of Spokane, Wash. recently received a distinguished achievement medal, the highest honorary award of the Colorado School of Mines.

Colonel Wm. S. Hunt, M.E.I.C. (McGill '36) has recently been appointed Canadian Military, Naval and Air Attache to Yugoslavia. Colonel Hunt was formerly electrical and mechanical engineer, Eastern Command, at Halifax.

W. L. McFaul, M.E.I.C. (Toronto '13) city engineer and manager of waterworks for the city of Hamilton, recently retired after many years of service.

Leslie Harold McManus, M.E.I.C. (Alberta '34) has been appointed Deputy Minister of Highways for the Province of Alberta.

D. C. Holgate, M.E.I.C. (McGill '38) formerly of Sault Ste. Marie is general manager of Dominion Bridge's Winnipeg Branch.


D. C. Holgate, M.E.I.C.


F. Allan Davis, M.E.I.C.

F. Allan Davis, M.E.I.C. (Queen's '40) has been appointed division engineer, Petroleum and Petroleum-Chemical Division, Foundation of Canada Engineering Corporation (Fenco), Toronto.

Dr. J. J. Green M.E.I.C. (Portsmouth '28) has been appointed chief superintendent of the Canadian Armament Research and Development Establishment, Valcartier, Que.

J. T. Dyment, M.E.I.C. (Toronto '29) chief engineer with Trans-Canada Air Lines, has been named a fellow of the Canadian Aeronautical Institute. The honour is for "notable and valuable contributions in aeronautical science or engineering."

John Campbell Sproule, M.E.I.C. (Alberta '30) of J. C. Sproule & Associates, Calgary, has been elected president of the Canadian Institute of Mining and Metallurgy in Montreal.

Robert L. Dunsmore, M.E.I.C. (Queen's '15), retired president of Champlain Oil Products, Montreal, and past president of the Montreal Board of Trade, was appointed chairman of the CBC Board of Directors on August 17. Mr. Dunsmore, whose new appointment is in effect until March 31, 1960, has been acting as chairman of the board since June, when CBC President J. Alphonse Ouimet became ill and Vice-President Ernest Bushnell went on vacation. Mr. Dunsmore up to this time has been chairman of the CBC finance committee.

F. Hugh Brennian, M.E.I.C. (McGill '44) is the new vice-president and general sales manager for Brencoat Sales Limited of Ville St. Pierre, Montreal.

H. W. Luckett, M.E.I.C. (Toronto '44) who heads the newly created Engine Sales Division of Sheridan Equipment, has been appointed Ontario distributor for Allis-Chalmers Engines.

Ben O. Baker, M.E.I.C. (Manitoba '40) has been appointed director of weapons research for The Defence Research Board in Ottawa.


Ben O. Baker, M.E.I.C.


R. A. Reid, M.E.I.C.

R. A. Reid, M.E.I.C. (McGill '42) has been appointed manager of manufacturing services at the Dominion Bridge head office in Lachine.

R. F. Martin, M.E.I.C. (Nova Scotia '42), city engineer with the St. John's Municipal Council, has been elected chairman of the Newfoundland branch of the Institute.

• PERSONALS

Emil J. Sanden, M.E.I.C. (Alberta '46) of the Alberta Department of Highways, has been appointed assistant chief engineer for the Province of Alberta.

V. E. McCune, M.E.I.C. (Alberta '46) has been named chief bridge engineer for the Department of Highways in the Province of Alberta.

D. E. Burnham, M.E.I.C. (Alberta '48) has been transferred by C.I.L. to the "Fabrikoid" plant in New Toronto, as assistant works manager.

Charles E. Garnett, M.E.I.C. has retired after forty years as president, and latterly as chairman, of Gorman's Ltd., Edmonton. He will remain a director of the company and devote his time to Edmonton Elevator Service of which he is president.

Kevin St. George, M.E.I.C. (N.S.T.C. '49), project engineer at Bowater's Newfoundland Pulp and Paper Mills, has been elected chairman of the Corner Brook branch of the Institute.

S. J. Medwadowski, M.E.I.C. (London '50) consulting engineer, is engaged in the private practice as a consulting structural engineering and in addition has been teaching and conducting research at the University of California.

D. W. Stairs, M.E.I.C. (McGill '48) is the new chairman of the Saguenay Branch of the Institute.

D. W. Stairs, M.E.I.C.

Ronald E. Pelkey, M.E.I.C.

Ronald E. Pelkey, M.E.I.C. (Saskatchewan '52), bridge design engineer with the Department of Highways and Transportation in Saskatchewan, has been awarded an Esso Good Roads Scholarship to the University of Illinois for postgraduate work in structural engineering with supplementary study in mathematics and soil mechanics.

John E. Rymes, M.E.I.C. (Manitoba '51) has been elected chairman of the Lakehead branch of the Institute. Mr. Rymes has been promoted to chief engineer, research and development, Canadian Car, Montreal.

Robert C. McDermott, M.E.I.C. (Toronto '51) has been appointed manager, Electric Products Sales, Eastern District, of Linde Company, division of Union Carbide Canada Limited, Toronto.

Alan J. Scott, M.E.I.C. (Durham '44) chief engineer of Consolidated Toronto Development Corporation has been elected president of the Urban Development Institute of Ontario.

B. W. Gilbert, M.E.I.C. (Toronto '48) of Linde Company, division of Union Carbide Canada, Toronto, has been appointed assistant manager, Gas Products Sales, Eastern District.

Dr. John L. Kearns M.E.I.C. (Iowa '54) has been appointed to the newly-established Abitibi Professorship in Engineering Science at the University of Western Ontario.

Alan J. Scott, M.E.I.C.

B. W. Gilbert, M.E.I.C.

Richard E. J. Putman, M.E.I.C. of Evershed & Vignoles (Canada), Toronto, has recently been appointed resident engineer, Western Canada.

L. R. Lauer, M.E.I.C. (Alberta '52) has been appointed sales engineer for the Toronto office of Canada Cement.

John E. Rymes, M.E.I.C.

Robert C. McDermott, M.E.I.C.

Richard E. J. Putman, M.E.I.C.

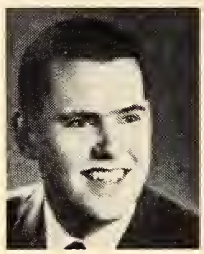
L. R. Lauer, M.E.I.C.

• PERSONALS

J. W. MacNeill, M.E.I.C. (Saskatchewan '58), formerly of Ottawa, has been appointed executive director of the South Saskatchewan River Development Commission, Regina.

J. W. MacNeill,
M.E.I.C.

J. W. Tremain, JR.E.I.C. (McGill '55) of Canada Cement, Ottawa, has been named sales engineer for the company's Edmonton office.



J. W. Tremain,
JR.E.I.C.

Reginald T. Giovannetti, JR.E.I.C. (Nova Scotia '52) has been promoted to plant engineer manager, Shore Establishments' East Coast Command, Department of National Defence, Nova Scotia.

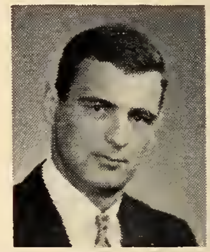
Reginald T. Giovannetti,
JR.E.I.C.

Arthur H. Abbott, JR.E.I.C. (New Brunswick '55) has taken a position with the Engineering Development branch of the Department of Public Works in Ottawa.

S. H. Phillips, JR.E.I.C. (Nova Scotia '52) has joined the Transport Department of The Toronto Star Ltd.

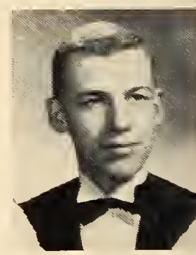
K. L. Currie, JR.E.I.C. (Queen's '56) has recently been granted a National Research Council Post-Doctoral Fellowship at Queen's University.

Jacques Charland, JR.E.I.C. (Laval, '57), traffic engineer with the Quebec Department of Roads. will do postgraduate work in traffic engineering at Yale University where he was awarded a Scholarship by the Canadian Good Roads Association.



Jacques Charland,
JR.E.I.C.

Bryan K. Johnston, S.E.I.C. (Manitoba, '36), resident engineer, Banff, Highways Division, Federal Department of Public Works, has been awarded a Standard Gravel Good Roads Scholarship to the Institute of Transportation and Traffic Engineering at the University of California where he will study for a master's degree in traffic engineering.



Bryan K. Johnson,
S.E.I.C.

Boris R. Hryhorczuk, S.E.I.C. (Manitoba '58), engineer with W. L. Wardrop & Associates, Winnipeg, has been awarded an Armco Drainage Good Roads Fellowship to do postgraduate work in city planning and traffic engineering at Yale University.

Desmond H. Annala, JR.E.I.C. (Queen's '57) is construction and waterworks engineer with the Public Utilities Commission of the City of Port Arthur.

J. E. Kean, JR.E.I.C. (N.S.T.C. '57) has left Canadian Standards Association Testing Laboratories in Toronto for the company's London, England office where his position will be that of electrical engineer.

S. E. Pearce, JR.E.I.C. (Queen's '48) of Canadian Westinghouse, Hamilton, has been named manager of their Mining, Petroleum and Chemical Section.

Arthur A. Sloane, JR.E.I.C. (Toronto '50) has become maintenance superintendent for North Star Oil (Refinery), St. Boniface, Man.

James G. Morrison, JR.E.I.C. (Nova Scotia '51) is general manager for Scotia Equipment, Halifax.

NEWS OF THE BRANCHES

Activities of the Fifty Branches of the Institute and abstracts of the papers presented at their meetings

HAMILTON

M. W. MacKenzie, JR.E.I.C., *Correspondent*

THE TENTH ANNUAL DANCE of the E.I.C. Hamilton Branch, will be held on Friday, September 25 at the Royal Connaught Hotel.

The committee announces there will be dancing from 9.00 p.m. to 1.30, with a midnight buffet.

R. T. Bailey is chairman of the dance committee which is anticipating a good crowd and a wonderful time.

KITCHENER

ON TUESDAY MAY 12, 1959, the wives of the executive met to discuss the formation of an E.I.C. Wives' Club. Mrs. Robertson of the E.I.C. Toronto Office, was present to answer questions and tell what the other wives' groups are accomplishing.

It was decided to hold a membership tea at the home of Mrs. Clare Leicht in Kitchener, on Tuesday, June 16, when one hundred ladies, wives of members of the branch, were to be invited to join the new club.

The following ladies agreed to act as an executive of the club: chairman, Mrs. L. J. R. Sanders, vice-chairman, Mrs. K. W. Kaye; Kitchener: Mrs. Walter Runge, Mrs. R. A. Dahmer, Mrs. W. Bobbie, and Mrs. Clare Leicht; Guelph: Mrs. F. H. Theakson and Mrs. G. E. C. Downing; Galt: Mrs. William Horner and Mrs. William Sheldon.

NIAGARA PENINSULA

J. H. Travers, JR.E.I.C., *Correspondent*

THE 6TH ANNUAL PROFESSIONAL ENGINEERS Ball will be held at Prudhommes Garden Centre on the Queen Elizabeth Way at Vineland, on Friday, September 25, 1959.

Publicity Director, J. H. Travers, promises these attractions:

- Music by Mart Kenney and his orchestra.
- A floor show, with two novelty acts
- Reception and cocktails at 6.00 p.m.
- Dinner at 7.00 p.m., dancing at 9.00 p.m.
- Cost, only $10.00 per couple.
- Refreshments.

OTTAWA

D. R. Grimes, JR.E.I.C., *Correspondent*

ELECTRONICS IN SOLIDS, SPACE AND SOUND was the subject of a demonstration lecture given on June 11, 1959, by Cyril N. Hoyler, manager of technical relations of the David Sarnoff Research Centre, R.C.A. Laboratories, Princeton, N.J.

The developments discussed and shown by Mr. Hoyler provide a dramatic progress report on the work of more than 250 R.C.A. scientists whose studies range over the broad areas of electronic materials, devices and systems. The results of this work lead to basic improvement and innovation in electronic techniques for the home, for industry, and for defense. Solid state electronics is the development and use of new solid materials within which electron action can be precisely controlled to achieve a variety of useful effects.

A NEW RECORD was established when 120 engineer golfers teed off at the Arnprior Golf Club on June 19, a fine sunny day, in the Fifth Annual Ottawa Valley Engineers Golf Tournament.

Participating in this tournament were members of the American Institute of Electrical Engineers, the Association of Professional Engineers of Ontario, the Corporation of P.E. of Quebec, the Canadian Institute of Mining and Metallurgy, the Chemical Institute of Canada. The E.I.C. Ottawa Branch was the sponsor for this year's tournament.

Hugh C. Brown was chairman of the 1959 committee, which included representatives from each engineering organization and three honorary members: Fred Wrangell, Blake Goodings, and Jack Melville.

The low gross prize was won by M. Ross of Ottawa with a score of 79; and the Quebec Corporation Trophy, emblematic of golf supremacy in Ottawa Valley Engineering circles, was presented to Mr. Ross by John S. Watt, chairman of the E.I.C. Ottawa Branch.

A. S. Lawson of Ottawa was runner-up, with a low gross of 80, closely followed by R. D. Watson of Deep River with 81. Some twenty prizes were presented at the dinner following the game.

Next year's tournament will be sponsored by the Association of Professional Engineers of Ontario.

SAULT STE. MARIE

THE E.I.C. WIVES' ASSOCIATION completed their first season in May. Organized in January, the group held a dinner in February, the annual meeting in March, and a social evening with a Chinese auction in May.

At the annual meeting officers were elected as follows: president Mrs. W. M. Hogg; vice-president, Mrs. G. L. Brown; secretary, Mrs. V. A. Graham; treasurer, Mrs. L. F. Mason-Tulby; chairman, publicity, Mrs. N. A. Paolini; chairman, membership, Mrs. A. D. Taylor; chairman, program and entertainment, Mrs. R. G. Sanders.

TORONTO

Harry Tryhorn, M.E.I.C., *Correspondent*

THE JOINT AREA COMMITTEE (a committee coordinating technical activities of Toronto branches of the E.I.C., the American Society of Civil Engineers, and the Institution of Civil Engineers) announces the fall program:

On October 22, 1959, E. G. Swenson of the National Research Council, will speak on "An Unusual Canadian Case of Cement Aggregate Reaction".

On November 19, 1959, W. E. Hickey, chief engineer, Foundation Co. of Canada, will talk about "Construction Engineering".

All meetings will be in Room E-21, Electrical Building, University of Toronto.

LIBRARY NOTES

ADDITIONS TO THE INSTITUTE LIBRARY • REVIEWS • BOOK NOTES • STANDARDS

BOOK 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.

DESIGN OF PLUMBING AND DRAINAGE SYSTEMS

This volume covers the basics of American plumbing design and practice, including plumbing codes, footing drains, water supply, cleanouts, etc. In addition it deals with some specialized topics, such as fire protection in tall buildings, services for research laboratories, motel systems, low cost housing projects, parking area drainage, animal quarter services and handling volatile fluid wastes.

The author of this detailed guide and reference book has had twenty years' experience in the field. (Louis Blenderman. New York, Industrial Press, 1959. 320p., $8.40.)

HANDBOOK OF AIR CONDITIONING, HEATING AND VENTILATING

The emphasis in this volume is on working data, and much of the information is presented in the form of tables, formulae, graphs and maps. The book is divided into eight sections, each of which has its own table of contents. There is also a detailed index to the whole volume.

The information given includes tables of heat losses from insulated pipe; heat losses through every standard type of window; data on steam flow in pipes; tables of heat losses from buildings; combustion data for fuels; design data for all standard pipe and tube, including plastics, etc.

Many experts have contributed to this Handbook, and the editor is the editor of Air Conditioning, Heating and Ventilating. (Ed. by Clifford Strock. New York, Industrial Press, 1959. irreg. paging, $17.00.)

*ELEMENTS OF PHYSICAL METALLURGY, 2ND ED.

Both the theory and practice of physical metallurgy are presented by treating current practical achievements in physical metallurgy as examples of fundamental principles. In this edition additions and revisions have been made throughout to bring the book up to date. The dislocation theory is introduced, while additional material on the electron theory of metals is given because of the increased importance of electric phenomena in semiconductors. A new chapter on phases in metal systems is also included. (A. G. Guy. Reading, Mass., Addison-Wesley, 1959. 528p., $9.50.)

INTRODUCTION TO ADVANCED DYNAMICS

An advanced undergraduate textbook, covering ideas of classical dynamics not usually discussed in courses on elementary mechanics, the emphasis being placed on basic principles. It deals with: 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; the Hamilton-Jacobi equation. References for further reading are included. (S. W. McCuskey. Reading, Mass., Addison-Wesley, 1959. 263p., $8.50.)

WATER TREATMENT

A concise practical survey of the methods of water purification and treatment now in use, intended primarily for industrial users, public health officials and swimming pool superintendents, although it will be of wider interest, especially the chapter on chemical and physical estimations.

The topics covered include collection and storage, filtration, chemical and other methods of treatment, effect of synthetic detergents, and mussel control. Although the emphasis is on standard British practice, the authors refer to papers published in other countries, notably the U.S.A., and these are listed in the four-page bibliography. (G. F. Mugele and A. Wiseman. London, Newnes, 1958. 141p., 21/-.)

ELSEVIER'S DICTIONARY OF NUCLEAR SCIENCE AND TECHNOLOGY, IN SIX LANGUAGES

Another of the multi-lingual dictionaries published by Elsevier, this volume contains over 4000 words in its basic list. The words are listed alphabetically in English, distinguishing British and U.S. usage, and defined. Corresponding terms in German, Spanish, French, Italian and Dutch appear on the opposite page. There is an alphabetical list for each language, keyed to the basic list. (Comp. by W. E. Clason. Toronto, Van Nostrand, 1958. 914p., $28.00.)

ELECTRICAL ENGINEERING: THEORY AND PRACTICE, 2ND ED.

Based on an undergraduate course, the emphasis is on the understanding of basic principles and processes, with equal attention given to the three major areas, circuits, machines and electronics.

In this enlarged edition, the section on electronics has been reorganized to include more material on the transistor and semi-conductor, and a new section has been added on magnetic amplifiers. Many more problems have been included. (W. H. Erickson and N. H. Bryant. New York, Wiley, 1959. 614p., $8.00.)

ELECTRONICS FOR EVERYONE, REV. ED.

Assuming no knowledge of electricity on the part of the reader, this volume explains in relatively simple language the history of electricity and its applications in condensers, batteries, coils and tubes, and later in radio, radar, television, both black and white and colour, x-rays, loran, satellite and missile electronics, electronic cookery, etc. There are many illustrations, and suggestions for further reading. (Monroe Upton. New York, Devin-Adair, 1959. 386p., $6.95.)

CONDUCTANCE DESIGN OF ACTIVE CIRCUITS

The techniques described in this volume for the use of conductance curves in the design of tube and transistor circuits have been developed over several years, and can reduce design and development time, and increase reliability. The topics covered include the basic principles; the problem of data presentation; design of simple circuits; impedance and power amplifiers; r-f and i-f amplifiers; special circuits; sine-wave oscillators; multivibrators and relaxation oscillators; mixers and detectors; transistor ampliers; high-frequency transistor circuits. There is a bibliography, mostly of periodical articles by the author, who is on the staff of the Ballistic Research Laboratories at the Aberdeen Proving Ground. (K. A. Pullen. New York, Rider, 1959. 330p., $9.95.)

*LINEAR STRUCTURAL ANALYSIS

A study of the equilibrium analysis of linear elastic structures. In this method the changes in geometry of the structures under load are sufficiently small to have

• LIBRARY NOTES

a negligible effect upon loads and their corresponding stress distributions, and the structural materials obey Hooke's law. This method of structural analysis is described in conjunction with linear matrix algebra techniques. Topics discussed include influence coefficients; indeterminancy; properties of matrices; computation; scale factors; stress resultant distributions, lack of fit and settlement; transformations; release system relations; flexibility matrix; and machine analysis. (P. B. Morice. Toronto, Longmans, Green, 1959. 170p., $7.00.)

°NUCLEAR ROCKET PROPULSION

Various aspects of the subject are discussed including heat transfer, structural analysis, fluid flow, thermodynamics, ballistic flight, reactor physics, and radiation safety. Many sections of the volume have applicability to all types of high-power density fission reactor design including mobile and ground power reactors. A feature is the detailed explanation, with examples, of the presently used methods of systems analysis. (R. W. Bussard and R. D. DeLauer. Toronto, McGraw-Hill, 1958. 370p., $11.50.)

DESIGN OF TRANSISTORIZED CIRCUITS FOR DIGITAL COMPUTORS

Written from the viewpoint of the circuit designer, the book is concerned with the design of transistorized digital computers and digital type circuits. Emphasis is on "worst-case" design techniques so that circuits can operate with resistors, voltages, transistor and diode parameters, simultaneously off their nominal values by the expected maximum tolerances.

Some of the topics covered include: basic building blocks in digital computers; diode gating; voltage-switching diode gate logic with transistor inverting amplifiers; direct-coupled transistor logic; design of flip-flops and delay multivibrators. (A. I. Pressman. New York, Rider, 1959. 316p., $9.95.)

CLASSIFICATION AND INDEXING IN SCIENCE

The flood of scientific literature appearing today has led many people to consider the use of machines for information retrieval, but as the author points out in his preface, behind every index or machine there must be an analysis of the subject matter.

This book discusses modern techniques of subject analysis, the construction of classification schedules, the classified catalogue (which is used in the Institute library), mechanical selection, indexing, and the future of information retrieval. (B. C. Vickery. Toronto, Butterworth, 1958. 185p., $5.50.)

INTRODUCTION TO STRESS ANALYSIS

A textbook for an introductory course in stress analysis, placing the emphasis on theory rather than empiricism. Some of the topics the author has included are: stress resultants in bars; stress and strain; uniform stress; flexure; shear stress; buckling phenomena; fatigue, creep, relaxation, etc.; plates and shells; strain energy; plasticity, elasticity and distortion. (C. O. Harris, Galt, Brett-Macmillan, 1959. 330p., $7.50.)

GENERAL CIRCUIT THEORY

Another in the series of Monographs on Physical Subjects, this book is a self-contained development of circuit theory. The emphasis throughout is on general relationships, and the text covers the general structure of circuits, general circuit theorems, linear passive four terminal circuits in the steady state, and in transients, and extensions to non-linear theory. (Gordon Newstead. London, Methuen, 1959. 144p., 15/-.)

°ELECTRONIC CIRCUIT THEORY

The authors' approach to electronics is based on circuit models so as to reduce the number of separate ideas and concepts required. In particular, piecewise-linear circuit models are used to convert a nonlinear circuit problem to a number of related linear problems. Thus, the mathematics of linear circuit theory can be applied to a broad class of physical circuits and systems operating in a non-linear manner. Models are devised to approximate the characteristics of diodes, triodes, pentodes, transistors, and other control devices, and graphical and geometrical interpretations of analyses are given. The effect of circuit and signal on device operation is shown by means of locus plots. Among the basic circuit functions considered are rectification and detection, waveshaping and amplification, and waveform generation. (H. J. Zimmerman and S. J. Mason. New York, Wiley, 1959. 564p., $10.75.)

°POWER PLANT THEORY AND DESIGN, 2ND ED.

A revised edition of the authors' "Steam Power Plants" that covers the entire range of power generating equipment, with particular emphasis upon the steam plant as the basic element. While giving principal attention to large central power station design, the book also discusses the smaller industrial plants, as well as gas, hydroelectric, and nuclear plants. Recent advances are given in the design of such equipment as cyclone furnaces, pressurized boilers and demineralizing equipment. The economic aspects of equipment selection receive increased emphasis and the proper selection of pipe sizes, insulation thickness, heater terminal differences, and station pressures and temperatures are fully discussed. (P. J. Potter. New York, Ronald, 1959. 710p., $10.50.)

°SYMPOSIUM ON SOLVENT EXTRACTION IN THE ANALYSIS OF METALS

Papers covering the following aspects: convergence of tie lines in ternary liquid systems and its application to liquid extraction; metals analysis with Thenoyltrifluoracetone; use of tri-n-octylphosphine oxide in analytical chemistry; 8-hydroxyquinaldine extractions applied to the analysis of metals; use of organic solvents in flame photometry. (Philadelphia, American Society for Testing Materials, 1958. s.t.p. no. 238. 54p., $2.25.)

°SYMPOSIUM ON RADIOACTIVITY IN INDUSTRIAL WATER AND INDUSTRIAL WASTE WATER

Because of the advent of nuclear power, new problems have been created in the field of industrial water techniques. Papers are presented which discuss problems in the reacior plant itself and in the associated water waste. Methods of analysis are described which include those for radiation hazards. (Philadelphia, American Society for Testing Materials, 1958. s.t.p. no. 235. 69p., $2.50.)

°SYNCHRONOUS MOTORS AND CONDENSERS

An introduction to the characteristics of synchronous motors and to the problems encountered in selecting the most suitable motor for a particular industrial application. In addition information is provided on associated starting and control equipment and on various aspects of protection for synchronous machines. A concluding section discusses synchronous condensers. (D. D. Stephen. Toronto, Ryerson, 1958. 500p., $12.00.)

SOVIET SPACE SCIENCE

Translated from the second Russian edition, published at the end of 1957, this book presents a good survey of astronautics, and although the emphasis is on Soviet achievement, the work being done in other countries is recognized.

With the emphasis on celestial mechanics and rocketry, the author discusses the laws of motion of artificial satellites, and their motion relative to an observer on the earth, construction and launching of a satellite, man in space, communication with the ground, the return to earth, artificial satellites of bodies of the solar system, and the use of artificial satellites.

The author, who commenced his career in France, has been concerned with astronautics for more than 25 years, and shows a great deal of knowledge of Western work in the field. (Ari Shternfeld. New York, Basic Books, 1959. 361p., $6.00.)

°FOUNDATIONS OF INFORMATION THEORY

An analysis of the mathematical theory of information. The author discusses the discrete channel with and without memory; the coding theorem for discrete channels without memory; the semi-continuous channel without memory; the binary symmetric channel. (A Feinstein. Toronto, McGraw-Hill, 1958. 137p., $7.50.)

ELECTRICITY AND MAGNETISM, 3RD ED.

The M.K.S. system of units has been adopted in this edition, necessitating considerable changes in the sections of the book dealng with electromagnetic and electrostatic theory, in addition to general revision throughout the book.

An elementary text, useful also for reference, the volume covers electricity and matter; effects of an electric current; magnetism; circuits; thermoelectricity; electrolysis; electromagnetism; measuring instruments; principles of electric machines; principles of electrostatics; elements of thermionics. (A. C. Hirst. Glasgow, Blackie, 1959. 438p., £2.)

FINANCIAL POST SURVEY OF OILS, 1959

According to this latest Survey, Canada's oil industry is going through a key period of consolidation which will set the pattern for future growth, and world events are pushing Canadian oil and gas into an increasingly important role. Details are given on active oil and gas companies in Canada, covering production, reserves, earnings, dividends, acreage interests and management. There are also special map sections and an eight-year price range of stock movements. (Toronto, Financial Post, 1959. 252p., $4.00.)

°SOLID STATE MAGNETIC AND DIELECTRIC DEVICES

An account of solid state devices and components using ferrites and titanates. The book begins with a classical treatment of magnetization and polarization and then proceeds to show the general application of these principles to electromechanical devices, small signal devices, ferrites at microwave frequencies, magnetic and dielectric amplifiers, digital techniques employing square loop materials, magnetic recording, and magnetic and dielectric measurements. Appendices discuss specialized aspects of the subject such as reciprocity in linear systems, magnetoresistance, and parametric devices. (Ed. by H. W. Katz. New York, Wiley, 1959. 542p., $13.50.)

THE ST. LAWRENCE SEAWAY

The first President of the St. Lawrence Seaway Auathority tells his inside story of the discussions and negotiations which went on between Canada, the U.S., and numerous other interested parties before construction of the Seaway began, and in its early stages, including the "battles" of the Montreal bridges and the tolls. He outlines the history of the earlier canals, the problems to be faced in building the Seaway, and how they were overcome. (Lionel Chevrier. Toronto, Macmillan, 1959. 174p., $3.50.)

THE ST. LAWRENCE SEAWAY

Professor Hills of the Geography Department of McGill University has written the story of the long chain of

● LIBRARY NOTES

events leading up to the construction of the Seaway and Power projects. He places the project in its geographical setting, and traces the early exploration of the system and early canals, to the end of the 14-foot canal era. He considers both the Canadian and U.S. views on the Project, and the work done before construction was started, and outlines the actual construction. In a final chapter he discusses the economic prospects of the Seaway, as distinct from the Power project which is an assured success. (T. L. Hills. London, Methuen, 1959. 157p., $2.50.)

SHIPS AND THE SEAWAY

In this book the general reader will find information about the Seaway, and the ships which sail it. The first section of the book describes the Seaway from the Gulf of St. Lawrence to the Lakehead, with a final chapter on measures taken to overcome the ice problem. The second section describes the ships of the different lines which will be using the Seaway, and the house flags and funnel colours of forty major shipping companies are illustrated on the end papers. (F. J. Bullock. Toronto, Dent, 1959. 115p., $3.95.)

*FAST REACTIONS IN SOLIDS

Deals with recent experimental investigations into the mechanism by which an explosion can be initiated in a solid, and in particular with the mechanism by which a crystal can decompose when subjected to heat, light, shock, or nuclear radiation. High resolution electron microscopy combined with electron diffraction is used to investigate the early stage of decomposition, and high-speed photography and fast electronic methods are employed to follow the rapid reaction. An important application of the subject matter is the accurate control of the burning of explosive materials. (F. P. Bowden and A. D. Yoffe. Toronto, Butterworth, 1958. 164p., $7.00.)

*SYMPOSIUM ON SOME APPROACHES TO DURABILITY IN STRUCTURES

Papers dealing with nonmetallic materials that are generally used in structures where weather plays a major part in the durability of the structure. The problems of variations of kinds of exposure and of associated moisture migrations are discussed. (Philadelphia, American Society for Testing Materials. s.t.p. no. 236. 67p., $2.50.)

*SYMPOSIUM ON ADVANCES IN ELECTRON METALLURGY

New and comprehensive techniques for the study of materials through the use of the electron microscope are described and include direct transmission electron microscopy, electron probe microanalysis, studies of the microstructure of age-hardenable and heat-resistant alloys, and improved techniques in specimen preparation and replication.

(Philadelphia, American Society for Testing Materials. s.t.p. no. 245. 120p., $4.00.)

°SYMPOSIUM ON CLEANING OF ELECTRONIC DEVICE COMPONENTS AND MATERIALS

Papers which discuss various aspects of the current knowledge concerning decontamination of electron devices, including both semiconductors and tubes. (Philadelphia, American Society for Testing Materials. s.t.p. no. 246. 220p., $6.50.)

°SYMPOSIUM ON BASIC MECHANISMS OF FATIGUE

Papers discussing the mechanisms of failure such as dislocations, internal friction, crytalline and structural changes, and surface disintegrations. In addition to clarifying the mechanisms leading to fatigue damage, the papers emphasize the statistical nature of the material behavior under cyclic loadings. (Philadelphia, American Society for Testing Materials, 1958. s.t.p. no. 237. 121p., $3.75.)

°AIR POLLUTION CONTROL

Presents the basic factors that should be considered in any air pollution control program. Beginning with an explanation of the effects of air pollution and the importance of meteorological variables, there follows a discussion of the nature and source of the more common air pollutants. Detailed consideration is then given to the methods of determining the amounts of various contaminants in the air, the most appropriate means of controlling emissions at the source, and the legal means available for control. Newer aspects such as the automobile exhaust problem and the hazards of radio-activity are also discussed. (W. L. Faith. New York, Wiley, 1959. 259p., $8.50.)

°AN INTRODUCTION TO CHEMICAL ENGINEERING

An introductory text that presents the fundamental concepts upon which chemical engineering is based. After preliminary material discussing chemical engineering as a career the authors discuss process variables, molecular units, compositions of mixtures and gases, PVT relations for gases, mixtures of gases and vapors, material balances, energy balances, and equilibria in chemical systems. (C. E. Littlejohn and G. F. Meenaghan. New York, Reinhold, 1959. 271p., $7.80.)

°FLUID-DYNAMIC DRAG, 2ND ED.

A comprehensive presentation of information on drag or fluid-dynamic resistance. The present edition has been extended to include the resistance of bodies in water, wind loads on buildings, and three new chapters dealing with aerodynamic drag at transonic, supersonic, and hypersonic speeds. Each chapter begins with theoretical aspects and provides references to fundamental papers on the subject. This is followed by diagrams, tables, and curves giving the known experimental measurements. Over 2000 references on the subject are included. (S. F. Hoerner. Published by the Author, Midland Park, New Jersey, 1958. 400p., $15.00.)

*REFRACTORIES BIBLIOGRAPHY 1947-1956

This volume continues the previous compilation which covered the period 1928-1947. Over 9,500 abstracts from the periodical literature and patents are included, and relate to the raw materials, manufacture, properties, and uses of refractories. Refractories in all phases of industrial use are covered, including glass industry, petroleum industry, and foundry refractories, as well as refractories for the iron and steel industry. Developments in high temperature materials are given particular emphasis. (Compiled by The Joint Refractory Committee of the American Iron and Steel Institute and The Refractories Institute. Toronto, Burns and MacEachern, 1959. 1822p., $9.50.)

*PLASTIC DESIGN IN STEEL

Methods are given for designing continuous steel structures on the basis of their ultimate or plastic strength. The chapters contained deal with plastic theory applied to bending, effect of axial load on bending resistance, shear and web crippling, bracing requirements, non-symmetrical sections, haunched connections, design of continuous beams, design of single span rigid frames, and design of multi-span rigid frames. (Toronto, Canadian Institute of Steel Construction, 1959. 93p., $4.00.)

*RADIATION HAZARDS AND PROTECTION

The nature of the radiation hazard is explained and the levels of radiation which are accepted as safe are presented. The authors then discuss the protective methods by which these safe levels can be attained, and the measurements that will show whether satisfactory conditions have been achieved. In a concluding section the radiological hazards arising from atomic warfare are examined, together with the protective measures possible. A considerable portion of the book is devoted to various types of instrumentation. (D. E. Barnes and D. Taylor. London, Newnes, 1959. 178p., 30/-.)

*INTERFERENCE BETWEEN POWER SYSTEMS AND TELECOMMUNICATION LINES

The problems posed by interference and their solutions are discussed at length in this monograph, which covers coupling between circuits, the characteristics of power systems that effect telecommunication systems adversely, the effects in telecommunication circuits arising from interference, telephone interference by induction at audio frequencies, variations in effects due to different types of power lines, and reduction of interference. An extensive bibliography is included. (H. R. J. Klewe. Toronto, Macmillan, 1958. 256p., $14.00.)

*CONDUCTION OF HEAT IN SOLIDS, 2ND ED.

This edition has been expanded to provide as complete an account of the subject as can be encompassed in one volume. To achieve this purpose, many new results have been added, and certain parts of the discussion have been extended, as is the case with heat generation, surface heating, geophysical applications, anistropic media, moving media, and substances with variable thermal properties. Three new chapters dealing with melting and freezing, integral transforms and numerical methods, as well as a number of new tables and text figures giving numerical information have also been added. (H. S.

(Continued on page 159)

Canmark Services Limited has been established to provide engineering sales and services across Canada. Formed by a group of 12 companies, of which Montreal Armature Works Ltd. is one, the new enterprise has headquarters in Toronto at 131 Bermondsey Road.

Piggott Construction Ltd. have placed an order of some 30 Caterpillar machines, including D9 and D8 tractors, scrapers and motor graders with Kramer Tractor Company, Ltd. The Piggott firm was successful bidder on Stage 2 of embankment work at the South Saskatchewan river dam project.

Quartzline lamps—The Canadian General Electric Company Limited have announced a new line of quartzline lamps which will be available first in 500-watt and 1500-watt sizes. The company's lamp department states that the growing line of pencil-thin tubular quartz lamps represents the first successful application of a repeating iodine cycle principle to lamp-making.

New Hardfacing Electrode—A new low hydrogen electrode, depositing a hardfacing weld metal of a new type is announced by ESAB Arc Rods Ltd., Montreal. It has, it is claimed, a very high degree of crack resistance with or without preheat.

Imperial Oil Limited have put out a revised edition of their booklet "Facts and Figures about Oil in Canada".

Atlas Asbestos Company Limited, manufacturers of "Turnall" asbestos-cement pressure and sewer pipe has released a 14-page guide to the writing of sewer pipe specifications. Available from any branch office of Atlas Asbestos Company Limited.

Hughes-Owens Co. Ltd., 1440 McGill College Avenue, Montreal, is the Canadian agent and distributor for optical instruments for the metal working industry manufactured by M. Hensoldt & Son, Optical Works, Wetzlar, Germany.

Public Works Contracts Awarded—Contracts involving expenditures totalling $5,993,610 were awarded by the Federal Department of Public Works during the month of May, 1959. During the month of June contracts awarded totalled $12,-863,810. The amount for new works in building construction and harbours and rivers engineering in May was $2,198,-802 and in June $7,585,266; for repair and maintenance of existing structures in May $270,520 and in June $1,-187,108; for the construction of highways and bridges in May $3,054,544 and in June $3,718,236; and for dredging in May $469,744 and in June $373,200.

Pirelli Cables, Conduits Limited appointment. Announcement has recently been made of the appointment of John J. Haines as technical representative for Pirelli Cables, Conduits Limited, attached to Head Office Sales Montreal.

FRONT BACK

CENTRE SPREAD

HONEYWELL CONTROLS LIMITED AWARD WINNING INSERT

The four page insert shown above has been voted the best in the June issue by the fifty readers who were asked to judge the advertisements in that issue. The judging was based on ACCURACY—INFORMATION and ATTRACTION. Please turn to pages 33 to 36 of your copy of the June issue to see the actual advertisement.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

The fifty readers who were asked to judge the advertisements in the June issue from the viewpoints of ACCURACY – INFORMATION – ATTRACTION, voted greatly in favour of the four page insert of HONEYWELL CONTROLS LIMITED, which appeared on pages 33 to 36.

The winning insert, printed in yellow, red, and black, features HONEYWELL'S new "ElectriK Tel-O-Set System". The copy describes in a very concise manner how the system functions. The use of colour in the advertisement makes it very dominating.

The insert was prepared and placed by Cockfield, Brown & Co. Ltd. of Toronto. The person in charge of advertising at the Company is Mr. K. K. Warne, Merchandising Manager.

When you need
High strength...
light weight... and top
insulating effectiveness

• LIBRARY NOTES

Carslaw and J. C. Jaeger. Toronto, Oxford University Press. 510p., $12.75.)

°ANALYSIS OF ELECTROPLATING AND RELATED SOLUTIONS, 2ND ED.

Over three hundred methods are given for the determination of principal constituents and impurities, together with chapters on sampling, and control of cleaners, the analysis of plating salts and of water, the physical and physicochemical methods of analysis, the preparation of standard solutions for volumetric analysis, and many tables. In this edition the text has been partially rewritten and forty new methods, mainly based on the use of ethylene diamine tetra-acetic acid, have been added. (K. E. Langford. Teddington, England, Robert Draper, 1958. 423p., $9.00.)

STANDARDS RECEIVED

ASTM standards. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

ASTM specifications for steel piping materials. $6.00.
ASTM standards on wood, wood preservatives, and related materials. $5.50.

Canadian standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2.

C22.2 No. 42-1959: Construction and test of receptacles, plugs, and similar wiring devices. 3rd ed. $1.75.

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Aeronautics

Experiments with screens and grids for suppressing jet engine noise, by H. U. Wisniowski. Ottawa, National Aeronautical Establishment, 1958. (Laboratory Report 231)

Amplifiers

Low-frequency amplifiers, ed. by A. Schure. New York, Rider, 1959. $1.80.

Automation

NOMA automation bibliography.
NOMA glossary of automation terms. Willow Grove, Penn., National Office Management Association, 1958. $2.00 each.

Cement and Concrete

Calcium chloride in concrete. 3rd ed. Washington, D.C., Calcium Chloride Institute, 1959.
Mineral aggregates: 1958 revision. Washington, Highway Research Board, 1958. (Bibliography 23)
A report on the visit of an American delegation to observe concrete and prestressed concrete engineering in the U.S.S.R. Chicago, Portland Cement Association, 1958.

Electrical engineering

E.R.A. thirty-eighth annual report. Leatherhead, Eng., Electrical Research Association, 1958.
Leading the world. London, British Electrical and Allied Manufacturers' Association, 1959. BEAMA Publication No. 168.

To those readers who searched the August issue in vain for Library Notes, our sincere apologies. Pressure on our space obliged us to omit this section at the last moment.

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

October 1959

vol. 42 no. 10

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 and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

MEMBERSHIP

ABC CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index
The Canadian Business and Technical Index.

(19,900 copies of this issue printed)

MEET THE AUTHORS

Professor A. G. Christie, M.E.I.C., Johns Hopkins University *(Some Considerations in Steam Power Plant Design).*

A graduate of Toronto University in 1901, Professor Christie holds several honorary degrees, including M.E., Dr.Eng. and LLD. He has worked for Westinghouse Machine Company, Allis-Chalmers Company and Western Canada Cement and he has taught at Cornell University, the University of Wisconsin, and Johns Hopkins University (where he became professor emeritus in 1948). Professor Christie is consulting engineer for the Hydro Electric Power Commission of Ontario, the Manitoba Hydro Electric Board and the New Brunswick Electric Power Commission.

G. D. Mader, chief engineer, Nova Scotia Power Commission *(The Interconnected Power Systems of Nova Scotia and New Brunswick).*

Mr. Mader received his B.Eng. (civil) from Nova Scotia Technical College in 1945. He joined Atlas Construction Company as construction engineer and transferred to the Nova Scotia Power Commission in 1950. He is a councillor of the Association of Professional Engineers of Nova Scotia and chairman of its board of examiners.

N. S. Haines, M.E.I.C., civil design engineer, Candu Nuclear Power Station, Hydro-Electric Power Commission of Ontario *(Whitedog Falls and Caribou Falls Generating Stations — Hydro Electric Developments on the Winnipeg and English Rivers).*

Mr. Haines graduated in 1935 from the University of Toronto with the degree of B.A.Sc. in civil engineering. He has worked as a field engineer in Northern Ontario; as research assistant on the International Tribunal on Smoke Control; and as consultant on overseas hydraulic work. Since 1940 he has been with The Hydro-Electric Power Commission of Ontario working on the design and construction of hydraulic developments.

E. K. Akin, M.E.I.C., senior mechanical engineer, Nova Scotia Light & Power Company Limited, *(The First Cyclone Fired Boilers in Canada and Some Aspects of their Early Operation).*

Mr. Akin received his early education in Windsor, N.S. and attended Dalhousie University. In 1934 he graduated from Nova Scotia Technical College with a B.Sc. in electrical engineering. He joined the Nova Scotia Light and Power Company Limited in 1935 and became superintendent of their steam plant in 1939. In 1950 Mr. Akin was made senior mechanical engineer.

T. Ingledow, M.E.I.C., president, B.C. Engineering Company Limited *(138 kv Under Sea Cable Across Georgia Strait).*

Mr. Ingledow joined B.C. Power Corporation (B.C. Electric Co. Ltd.) as chief engineer in 1940; became executive engineer of the B.C. Power Corporation and was president of B.C. Eng. Co. Ltd. from 1954 to 1958, when he became president of the newly-formed company, B.C. & B.B. Power Consultants, in 1958.

A member and past president of the Association of Professional Engineers of British Columbia, Mr. Ingledow is also on the Defence Research Board of Canada.

George S. Cavadias, M.E.I.C., consulting engineer, Montreal, Que. *(A Method of Determining the Power Potential of Rivers with Many Reservoirs and Power Plants).*

Mr. Cavadias graduated in civil engineering from the National Technical University, Athens, Greece, in 1942 and worked on structural and hydro-power engineering before coming to Canada in 1950. He has worked with the Shawinigan Water and Power Company and the Department of Northern Affairs and National Resources. Mr. Cavadias recently obtained an M.Sc. degree from McGill and in August, 1959, established his own consulting practice in Montreal.

Winnett Boyd, M.E.I.C., president, Winnett Boyd Limited *(The Design of a Daniels-Boyd Nuclear Steam Generator for a 400 Mw (Net E) Power Plant).*

Mr. Boyd graduated from the University of Toronto in 1939 in mechanical engineering and did post graduate work at M.I.T. From 1940 to 1943 he was with the Aluminum Company of Canada in British Guiana, Montreal and Shawinigan Falls. As chief designer at A. V. Roe Canada Limited, he designed Canada's first two jet engines, the Chinook and Orenda. From 1951 through 1956 he was chief mechanical engineer with C. D. Howe Company Limited on design of the NRU reactor. Since 1957 he has worked on the Daniels-Boyd Nuclear Steam Generator and is now in practice as consulting engineer. He is a registered professional engineer in Ontario and Quebec and is a fellow of the Canadian Aeronautical Institute.

J. A. Paget, M.E.I.C., General Atomic Division, General Dynamics Corporation, La Jolla, California *(The Design of a Daniels-Boyd Nuclear Steam Generator for a 400 Mw (Net E) Power Plant).*

Mr. Paget graduated from the University of Toronto in 1946 with a degree in mechanical engineering. In 1952 he joined The C. D. Howe Company Limited, Montreal on the NRU project, later working with the Daniels-Boyd Reactor Group; in 1958 he was engaged on the CANDU steam generator design; and in August, 1959, he joined the John J. Hopkins Laboratory of General Atomic as a member of the research and development staff. He is a registered professional engineer in the provinces of Quebec and Ontario.

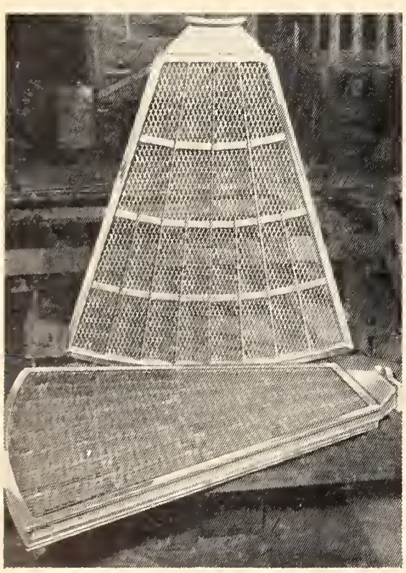
Paul Hamel, engineer, Atomic Products Section, Orenda Engines Ltd. *(The Design of a Daniels-Boyd Nuclear Steam Generator for a 400 MW (Net E) Power Plant).*

Mr. Hamel graduated from Ecole Polytechnique, Montreal, in 1942, in mechanical engineering and did post-graduate work from 1954 to 1956. Employed by the C. D. Howe Company in 1954, he worked on the NRU reactor. In 1957 Mr. Hamel spent six months at Chalk River studying reactor physics and the use of digital computers. From 1957 to mid-1958 he worked on the Daniels-Boyd Nuclear Steam Generator. He recently joined the Atomic Products Section of Orenda Engines Company, Malton, Ontario. Mr. Hamel is a registered professional engineer in Quebec.

Silver Falls Generating Station. Biographical notes on the authors of this paper will appear in the next issue of *The Engineering Journal.*

Incoloy tubing installed in a large furnace for converting ethane to ethylene. Very little tube maintenance or downtime required in spite of the 1500°F. temperature of operation. Tube wall temperatures are about 1700°F.

NICKEL ALLOYS withstand high resist corrosive processing and



Expanded Monel and Inconel metal for use as backing screens in disc-type filters in pulp and paper industry. Frame is fabricated type 316 or 304 stainless steel.

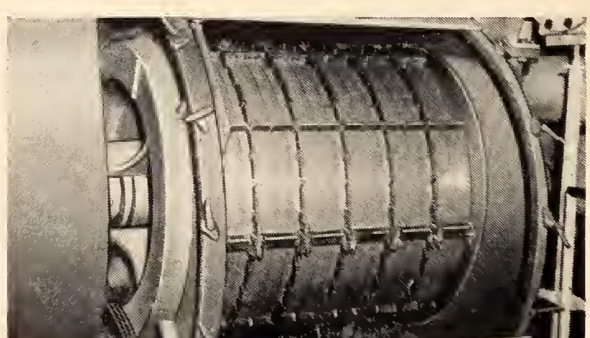
Three Inco Nickel Alloys . . . MONEL, INCONEL and INCOLOY . . . fulfill most requirements where high temperature and corrosion problems are encountered in chemical processing and pulp and paper production.

MONEL* is a strong, tough nickel-copper alloy that resists attack by many organic and inorganic acids, alkalies and salts. Monel has good mechanical properties, is easily fabricated and welded.

INCONEL* nickel-chromium-iron alloys have good resistance to oxidation up to 2100°F. and retain good mechanical properties at temperatures up to 1800°F. Excellent resistance to sulphur-free heat-treating atmospheres. Practically immune to embrittlement by carburizing or nitriding atmospheres.

INCOLOY* provides good strength characteristics and—like Inconel—good resistance to oxidation and other corrosive conditions at high temperatures. Incoloy also gives greater resistance to sulphur attack, green rot and molten cyanide salts.

**Trademarks*



Type A Cowan centrifugal pulp screen with Monel perforated screen plates at Dryden Paper Company Limited, Dryden, Ont.

INCO
TRADE MARK

POWER IN CANADA

Net Generation up 6.3% in first seven months of 1959

PRODUCTION of electrical power in Canada during the first seven months of 1959 continued to rise over the output for previous periods. Net generation as reported by Dominion Bureau of Statistics refers only to firms which generate at least 10 million kwh. a year, but these represented 99.1% of total production in 1957.

On this basis, net generation in the first seven months of 1959 totalled 59,414,323 Mwh. compared with 55,898,132 Mwh. in the same period of 1958, representing a gain of 6.3%

About four-fifths of this total was produced by power utilities, the rest by industrial producers. An approximate breakdown of net generation for the period January-July 1959 is:

Utilities	*% of total*
Hydro	74.3
Thermal	5.2
Industry	
Hydro	18.5
Thermal	2.0

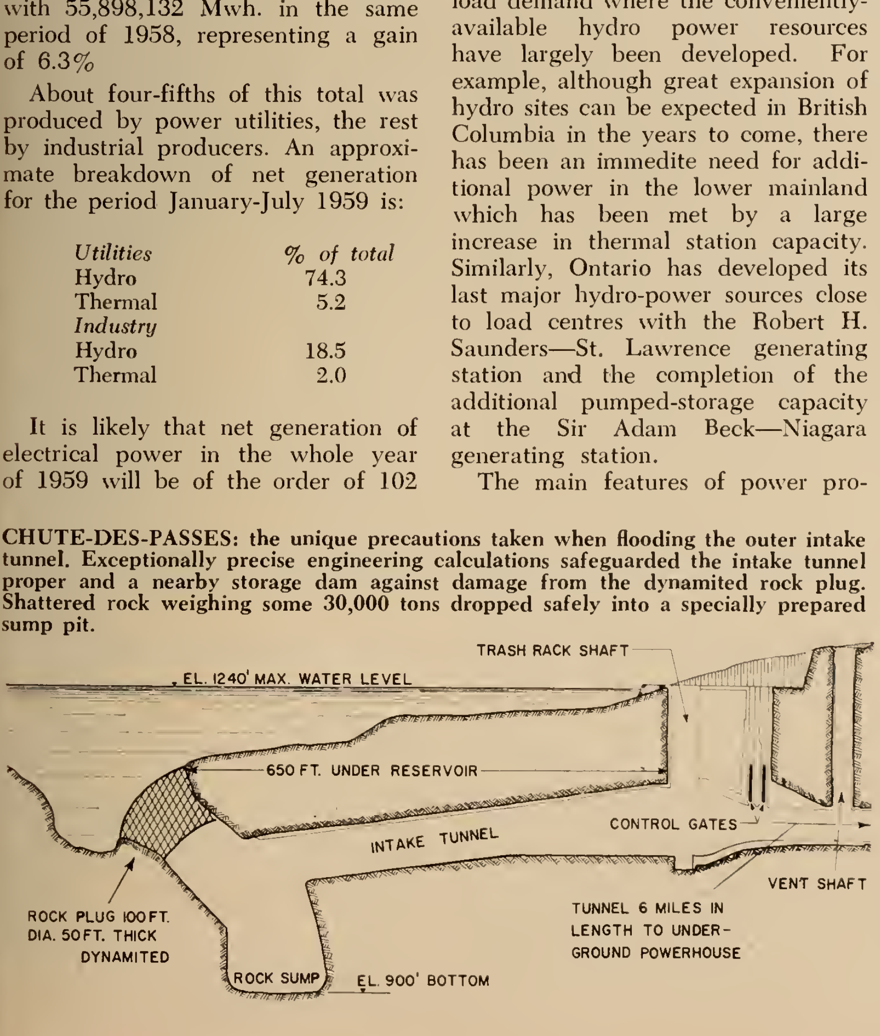
It is likely that net generation of electrical power in the whole year of 1959 will be of the order of 102 million Mwh., compared with the 1958 total of 96,743,717 Mwh.

Hydro/Thermal Generation

Installed capacity of water-power plants at the end of 1958 totalled some 22,470,040 h.p., and the total for thermal generating plants was about 3,660,000 h.p. The relative growth rate of thermal power expansion is increasing over that for hydro power because of the need to increase base load capacity in areas of high load demand where the conveniently-available hydro power resources have largely been developed. For example, although great expansion of hydro sites can be expected in British Columbia in the years to come, there has been an immedite need for additional power in the lower mainland which has been met by a large increase in thermal station capacity. Similarly, Ontario has developed its last major hydro-power sources close to load centres with the Robert H. Saunders—St. Lawrence generating station and the completion of the additional pumped-storage capacity at the Sir Adam Beck—Niagara generating station.

The main features of power production across Canada will be dealt with briefly by individual provinces and territories.

CHUTE-DES-PASSES: the unique precautions taken when flooding the outer intake tunnel. Exceptionally precise engineering calculations safeguarded the intake tunnel proper and a nearby storage dam against damage from the dynamited rock plug. Shattered rock weighing some 30,000 tons dropped safely into a specially prepared sump pit.



BRITISH COLUMBIA

At the end of 1959 in British Columbia there were 40 hydro-electric installations with an installed capacity of 3,287,505 h.p. in the category of stations with installed turbine capacity of not less than 2000 h.p. A further 510,000 h.p. was under construction, or planned for development.

Aluminum Company of Canada Limited had the largest single installation with 1,050,000 h.p. from seven units at the Kemano-Kitimat development in the northern part of the province. Expansion to the total potential of 2,400,000 h.p. at this site will take place when warranted by business conditions.

British Columbia Electric Company Limited will have two out of four generating units installed this fall at their Bridge River No. 2 site, which will add some 345,000 h.p. to the B.C.E. hydro capacity when completed in 1960. Total cost will be about $56.5-million.

In the thermal field, B.C. Electric will complete the 134,000 h.p. stand-by gas turbine plant at Port Mann this fall. Work is progressing on the Company's largest undertaking, the Burrard thermal station, which is a natural gas fired, steam-driven plant, of which the first 200,000 h.p. generating unit will be in service in 1961. Three others will be brought on line between 1961 and the end of 1964, and the plant can be expanded to house six units with a total capacity of 1,200,000 h.p.

British Columbia Power Commission is also actively expanding its resources. Most recently completed additions, which were officially commissioned on 2nd September 1959, are the 100,000 h.p. capacity Georgia gas-turbine generating station near Chemainus and the 35,000 h.p. Ash River hydro station near Port Alberni, both on Vancouver Island. The two plants raise the Power Commission's generating capability within the province to 600,000 h.p., which is estimated to be sufficient for demands until the early nineteen-sixties. A further expansion now under way is the addition of a 3000-kw. gas-diesel generating unit at Quesnel, which will boost the capacity of the station to 15,000 kw. This is part of an extensive expansion program of Power Commission gas-diesel and diesel generating stations at Prince George, Dawson Creek, Quesnel, Smithers, Chetwynd, and Alert Bay. The new unit at Quesnel is due to be in service by May 1960. The Commission serves many small centres in relatively remote areas and, at March 31, 1959, had 78 diesel and gas-diesel generating sets, including some 500-kw. mobile units, with a total capacity of 62,001 kw.

The overall picture of power generation in British Columbia in the future will be greatly affected by the ultimate results of negotiations and planning for the two controversial projects on the Columbia and Peace Rivers. Development of the Columbia has, as is well known, depended on lengthy discussions with United States authorities on such problems as downstream water rights. The Wenner-Gren group has had the backing of the B.C. Premier, Mr. Bennett, to develop its plans for production of a possible 4 million h.p. on the Peace River, but the Federal Government has taken the view that the project is not economically feasible at present, for want of a sufficient market. However, the future of these two great projects will be watched with much interest.

YUKON AND NORTHWEST TERRITORIES

The Northern Canada Power Commission of the Federal Government completed its 15,000 h.p. hydro installation at Whitehorse Rapids, Y.T., in 1958, and has plans for a further unit of 7,500 h.p. at this site. The Commission's other hydro sites are on the Mayo River, Y.T. (6000 h.p.), and Snare Rapids, N.W.T. (8350 h.p.). A second development on the Snare River, eight miles downstream from the present site, will have a capacity of 9,200 h.p.

Other major hydro plants are the 15,000 h.p. installation of Yukon Consolidated Gold Corporation on the Klondike River, which was developed between 1911 and 1935, and the Consolidated Mining and Smelting plant of 4700 h.p. at Bluefish Lake, Klondike River, N.W.T., which was installed in 1941.

Recent thermal plants include a 600 kw. unit at Fort Smith and a 150 kw. diesel unit at Inuvik (formerly New Aklavik).

There is a potential of some four-million h.p. on the Yukon and Nass Rivers under investigation by Northwest Power Industries Ltd.

ALBERTA

At the end of 1958 there were 12 hydro developments in Alberta with installed turbine capacites over 2000 h.p. The capacity of these totalled 310,510 h.p.

Calgary Power Limited operated eleven of these hydro plants (240,000 kw.) and present expansion consists of an additional 80,000 kw. at the Spray-Rundle plant, to be completed in 1960. Application has been made for construction of a dam and hydro generating plant on the Brazeau River (a tributary of the North Saskatchewan) 96 miles S.W. of Edmonton. At a cost of $45 million the initial capacity will be 150,000 kw., to be complete in 1964, though some power should be available in the Fall of 1963. The project will require the construction of a 10-million cu. ft. earthfill dam, two miles long, with a twelve-mile long canal to carry water from the 900,000 acre-ft. storage reservoir to the powerhouse.

Calgary Power's Wabamun thermal plant now produces 144,000 kw. from two units, using natural gas as fuel. An additional 150,000 kw. unit is scheduled for completion at this site by 1962. There is a reserve of 70 million tons of coal at Wabamun, which can be developed by strip mining, and eventually the thermal power plant will operate on coal, though natural gas will be replaced only as coal is economically available and will continue to be used for emergencies and as a pilot for coal-firing.

There is an interesting relationship between the growth of the oil and gas industry in Alberta and the growth of the electrical power demand in the Province. In 1947, the year of the Leduc discovery, Calgary Power supplied the oil industry with 2,089,400 kwh. of electrical energy (1.2% of the industrial load or 0.5% of the total load). In 1958 the supply had risen to 212,816,562 kwh. or 34% of the Company's industrial load (14.8% of total load). This great increase in demand for power by the petroleum industry has had a considerable effect on the planned expansion of the power industry.

The Canadian Utilities Limited are spending $2,680,000 on capital expansions during 1959, particularly for transmission line extensions. Other large expenditures are planned for the Company's northern subsidiaries, McMurray Light and Power Co., Yukon Electrical Co., Ltd., and Yukon Hydro Co. Ltd. (Whitehorse, N.W.T.). A 200 kw. diesel plant and distribution system was built in 1958 to serve the rapidly-growing oil centre of Swan Hills. During 1959, the Company is building a 150 kw. diesel generating plant to serve the community of Fort Chipewyan in northern Alberta.

SASKATCHEWAN

Saskatchewan had only two hydro installations at the end of 1958 with capacity of over 2000 h.p. The 106,500 h.p. Island Falls plant (Churchill River) of the Churchill River Power Company has an additional unit of 19,000 h.p. completed this year.

The big development in the province is the South Saskatchewan River project for which a 200,000 h.p. hydro-electric installation is planned.

Since the end of 1957, when there were 14 thermal generating stations in the over-2000 h.p. category, the Saskatchewan Power Corporation has added a 66,000 kw. steam turbine to its Queen Elizabeth station in Saskatoon and increased capacity of the Kindersley station by 20,000 kw. in two gas turbine units.

MANITOBA

Eight hydro-electric developments (over 2000 h.p.) at the end of 1958 had a combined capacity of 777,000 h.p. Of these four were operated by the Manitoba Hydo-Electric Board (562,000 h.p.), two by the City of Winnipeg (201,000 h.p.), and two by Sherritt-Gordon Mines Ltd. (Laurie River Nos. 1 and 2, each of 7000 h.p.).

The Manitoba Hydro-Electric Board is proceeding with the Kelsey hydro-station on the Nelson River in northern Manitoba, which will supply power to the International Nickel mining development at Moak, Mystery, and Thompson Lakes. Two 42,000 h.p. units are scheduled for completion in 1960 plus three more in 1961. When completed, this project will bring the normal winter generating capability on the Manitoba Southern Power System to over one-million kw., from 870,000 kw. in 1960 and 416,000 kw. in 1950.

The Board is making engineering investigations at the Grand Rapids site on the Saskatchewan River. The site has a potential of over 400,000 h.p. and is being considered for development with a head of 120-125 ft. Another program of investigation is under way at the Great Falls generating station to consider the advisability of increasing capacity from the present 132,000 kw.

The Board's thermal station at Brandon is rated at 132,000 kw. (see *The Engineering Journal*, July 1959) and was completed late in 1958. A further 132,000 kw. of thermal generating capacity will become available when the Selkirk station produces from its first stage in 1960. Provision has been made for further expansion of the Selkirk plant to a maximum of one-million kw.

The possibility of a four-million kw. system in Manitoba by 1980 has been considered, and this would probably include a capacity of one-million kw. at Selkirk and some two million from exploitation of the hydro potential of the northern rivers: about 300,000 kw. from the Grand Rapids site and the rest from sites on the Nelson River. The remaining one-million kw. might come from the Winnipeg River, where rather more than half this amount is now being developed. Actual development depends on the economics of the various forms of power generation, including that from nuclear energy.

In the field of transmission, the Manitoba Hydo-Electric Board has a project for a 150-mile 138-kv. line between Manitoba and Saskatchewan.

The 51,000 kw. capacity of the City of Winnipeg Amy Street thermal station will form part of the intergration of resources, both thermal and hydro, of the Board and the City, and investigations have been made towards integrating the resources of the northwest pool of Ontario Hydro and those of the industry in Manitoba.

ONTARIO

At the end of 1958 Ontario reported 105 hydro generating stations of capacity greater than 2000 h.p. for an installed capacity of over 7,080,000 h.p. By the end of 1959, when the last of the sixteen units at the Robert H. Saunders-St. Lawrence station is in service, a further 525,000 h.p. will have been added (for a total of 1,200,000 h.p. at the St. Lawrence project.

Most of the hydro development in the province is controlled by the Hydro-Electric Power Commission of Ontario (Ontario Hydro), with 67 hydraulic stations and a total capacity of 5,761,100 kw. Industry, particularly pulp and paper and some mining and smelting operations, accounts for a further capacity of over 637,000 kw.

Ontario Hydro progress in 1958 has been discussed earlier (*The Engineering Journal*, May 1959), and 800,000 kw. of new generation was added in that year. At the end of the year, work was in progress on nine stations: five hydraulic, three conventional thermal, and one nuclear-electric. As already mentioned, the Robert H. Saunders-St. Lawrence hydraulic station at Cornwall will be completed in 1959. Silver Falls generating station, on the Kaministikwia River about 30 miles northwest of the Lakehead, is scheduled to produce 45,500 kw. in September 1959. Red Rock Falls station, on the Mississagi River about 14 miles northeast of Thessalon, is scheduled for completion in 1961, when it will have a capacity of 38,000 kw. Otter Rapids generating station is being built at the lower end of a series of rapids on the Abitibi River and will produce 31,000 kw. when completed in 1961. A further 45,000 kw. capacity was added in 1959 to the existing 181,000 kw., Abitibi Canyon station, 50 miles northeast of Kapuskasing, the largest generating station in northern Ontario.

At the end of 1957 there were 13 thermal stations in the province of capacity greater than 2000 h.p. for a total capacity of 967,300 h.p. The largest of these is Ontario Hydro's Richard L. Hearn steam plant in Toronto, on which work is proceeding to increase capacity from 400,000 kw. to 1,200,000 kw. by 1960, at an estimated cost of $107,600,000. The new Lakeview station, on the shore of Lake Ontario a few miles west of Toronto, will be among the largest thermal-electric plants in the world. It is scheduled to begin operation in 1961 with one 300,000 kw. unit, and a second unit of the same size is to be added the following year. A total installed capacity of 1,800,000 kw. is planned for the middle 1960's at an estimated cost of $250 million. The third thermal station on which Ontario Hydro is working is that at Thunder Bay, at the mouth of the Mission River on the Fort William waterfront. Initial plans call for a single 100,000 kw. unit, to be in operation in 1961, but the site is large enough for the ultimate construction of a 1 million kw. station.

Nuclear Power

Canada's first nuclear-electric generating station is the NPD (Nuclear Power Demonstration) plant, now being built in co-operation with Atomic Energy of Canada Limited (A.E.C.) and the Canadian General Electric Company on the banks of the Ottawa River 150 miles northwest of Ottawa. Scheduled to be completed in 1961, the relatively small 20,000 kw. station will be operated and maintained by Ontario Hydro, who are also working with the Nuclear Power Plant Division of A.E.C. on plans for a 200,000 kw. nuclear plant known as CANDU (Canadian Deuterium Uranium). The objective is to produce electricity competitive with conventional thermal generation, and it is expected that power from CANDU will be fed into the Ontario Hydro system by 1965 or even earlier.

Other recent advances by Ontario, in addition to considerable expansion of transmission and distribution facilities, included the experimental extra high voltage transmission line, near Coldwater, for testing up to 600,000 volts. Completed in 1959, this is the first three-phase test line of this voltage in North America; the use of extra high voltage transmission will be the best means of carrying power over long distances, for example, from far northern hydraulic sites, and of integrating more fully the northeastern and southern Ontario systems. The second notable development was the introduction of an electronic data processing system in the head office in Toronto (see *The Engineering Journal*, August 1959).

Apart from the developments of Ontario Hydro, the Great Lakes Power Company this year started operation of the Cat Falls 30,300 h.p. hydro-unit on the Michipicoten River.

QUEBEC

The province of Quebec depends

almost entirely on hydraulic generation for electrical power. At the end of 1958, in the over-2000 h.p. category, there were 92 hydro installations with a combined capacity of some 9,784,000 h.p., compared with only seven small thermal stations (over 2000 h.p.) with a capacity of 36,584 h.p.

Many organizations are involved in the development of hydro-electric power, but the leaders are Hydro-Quebec, Aluminum Company of Canada Limited, and Shawinigan Water and Power Company in terms of installed capacity.

Hydro-Quebec (Quebec Hydro-Electric Commission) is proceeding with construction of the Bersimis II development on the Bersimis River, at which three units of 171,000 h.p. each are scheduled for completion in the last two months of 1959, and two further units for late in 1960. The 1,200,000 h.p. Bersimis I plant was completed in 1958. At Beauharnois, on the St. Lawrence River, the third and final section of the powerhouse is under construction with two out of eleven units of 73,700 h.p. installed. Completion is due in 1961, when the station will have a total installed capacity of 2,234,700 h.p.

The Aluminum Company of Canada had a capacity of 2,600,000 installed h.p. from five stations, including the 1,200,000 h.p. Shipshaw development, at the end of 1958. Now under construction is the new project at Chute-des-Passes, 150 miles north of the aluminum centre of Arvida, Saguenay District, where the first 200,000 h.p. unit was due to operate in September 1959. The further four planned units are scheduled for completion early in 1960, for a total capacity of 1 million kw.

The most recent development of the Shawinigan Water and Power Company is the 330,000 h.p. Beaumont plant, on the St. Maurice River, completed in 1958.

Several other developments are now under way. Quebec Mining Company has a 66,000 h.p. three-unit development on the Hart Jaune River scheduled for operation by late 1960. James MacLaren Company Limited is completing a two-unit 50,000 h.p. development at Dufferin Falls, Lievre River, and removing the existing 1500 h.p. plant in Buckingham from service. Hollinger-Hanna Limited is investigating possible development of 150,000 to 180,000 h.p. on the Aux Pekans River.

Quebec Department of Hydraulic Resources is continuing water power investigations on several rivers in the James Bay, Ungava Bay, and St. Lawrence River watersheds.

NEW BRUNSWICK

The New Brunswick Electric Power Commission reports hydro-electric power capacity of the province in 1959 at 194,030 kw. from ten stations, four of them operated by the Commission. Thermal capacity is given as 192,576 kw. from twelve stations plus diesel generator installations. The Commission's share of the total is rather more than one-half at 196,610 kw.

The Beechwood hydro station, completed with two 45,000 h.p. units in 1958, is designed for future addition of a further unit of the same size.

Latest addition in the thermal field is the new 50,000 kw. plant at St. John, which will serve, among other customers, the nearby Irving Oil refinery which is now under construction.

A feature of the power developments in New Brunswick is the interconnection of generating systems and extension of the new 138 kv. transmission grid. The five major pulp and paper companies operating in the province are partners in the reciprocal arrangement for distribution, and there is a tie-in with the Maine Public Service Company, which serves the northern part of the State. By March 1960 the systems in the province of Nova Scotia will be added to the power pool.

NOVA SCOTIA

Nova Scotia has the poorest water-power resources of the mainland provinces. Though 26 hydro stations of over 2000 h.p. capacity were reported at the end of 1958, the total capacity was only 168,290 h.p. Thermal generation reported at the end of 1957 amounted to 462,046 h.p. from eleven installations.

The Nova Scotia Power Commission has a hydro development on the Sissiboo River, consisting of two plants totalling about 15,000 kw., scheduled for completion by the end of 1959. Two sites on this river, capable of producing an additional 12,000 kw., will be built for completion in 1963. An investigation is underway on the hydro development at Wreck Cove, Victoria County, which is expected to have an ultimate capacity of 74,000 kw. Scheduled to go into service this fall is an additional 20,000 kw. unit at the Trenton steam station and, though additional thermal plants are not foreseen in the immediate future, long-term plans include two additional units at Trenton which would be rated at 75 Mw. and 100 Mw. respectively.

Nova Scotia Light and Power Company Limited will commission their 45,000 kw. No. 7 plant addition to the Water Street thermal generating station on 30th October 1959, which will bring the combined capacity of the Company's thermal and hydro facilities to 204,500 kw. A site has been procured, and engineering design is well advanced for a new thermal generating station at Tufts Cove, on the Dartmouth side of Halifax Harbour. The first unit will be in the 100 Mw. class and is scheduled for operation in 1963. The Company has also announced plans for the construction of two hydro-electric stations in the Annapolis Valley, at Alpena on the Nicteaux River and at Lequille. These will add 14,000 h.p. to generating facilities in the Valley. Lequille is scheduled for operation in 1961; Alpena in 1963.

PRINCE EDWARD ISLAND

Water power resources are negligible in Prince Edward Island, because of the small size of the streams. Less than 2000 h.p. of installed turbine capacity is developed at present. There are two major thermal installations, the principal one being the Maritime Electric Company steam plant at Charlottetown with 22,500 kw. capacity. To meet increasing demand for power, the Company is installing a new oil-fired boiler and 10,000 kw. generator at the plant site. The new 105,000 lb. hr. boiler is to be in use by september 1960, and the new turbo-generator by May 1961. A new central control room is to be included in the extension, and provision will be made for eventual automation of the plant and remote control of the company's sub-stations throughout the province.

NEWFOUNDLAND AND LABRADOR

At the end of 1958, nineteen hydro installations (over 2000 h.p.) were reported in Newfoundland with a total capacity of 361,750 h.p. Six thermal stations had a combined ca-

(Continued on page 95)

SOME CONSIDERATIONS IN STEAM POWER PLANT DESIGN

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STEAM PLANTS that are designed today require large investments which are expected to be written-off during a service life of from 25 to 30 years. Consideration must therefore be given to desirable characteristics and elements of such new plants.

Large generating units

A common mistake in the design of new power plants is the failure to install large generating units. Equipment is purchased that appears to meet the immediate needs of the system. This practice disregards the fact that in twenty-five years at the present rate of growth, system peak demands will be over four times the present peaks. This rapid system growth soon makes the selected unit relatively so small and inefficient that it is held only for reserve and for occasional peak load service.

The advantages of large interconnected systems have been fully demonstrated. This recognition has led to the formation of power pools in various sections of the country with the objective of lessening the amount of reserve equipment of the interconnected system and of adding large highly efficient generating units to provide service to the whole pool at minimum cost. Agreements are made to share fixed charges of these large units and to adjust costs of kilowatt-hours delivered to each pool member.

Where hydraulic power plants with large storage reservoirs are elements of a system, large steam units can be added to carry base loads, leaving the hydro units to care for peak loads by short-time draw-down of storage. Experience has indicated that additional generating capacity for peak load service can often be added at such hydro plants at a lower cost per kilowatt of capacity than by any other peak load equipment. Present and future hydro plants should be analyzed with this object in mind.

The installation of large generating units, designed for operation at high steam pressures and temperatures, is justified by the preceding considerations. Large units can be purchased at a lower cost per kilowatt of capacity than smaller units. High steam pressures and temperatures lead to low heat rates; this is a desirable feature in view of expected increases in fuel costs. The same size of operating staff can serve a large unit as a small one, thereby reducing labour cost per kilowatt-hour. Maintenance charges per unit of output appear to be independent of capacity. Hence lower total generating costs can be expected of the large units when given base loading.

The operating records of large units have indicated high factors of availability and reliability which are as good as those of smaller units.

Large units can provide greater capacity on a desirable plant site than smaller machines. This is an important factor, for suitable power plant sites near large cities are becoming scarce. It is essential that available sites for future steam plants be purchased ten or more years in advance of their need. Otherwise such sites may be unavailable later.

High plant efficiency

Increasing mining costs combined with decreasing heat values per pound of coal, make it imperative that new units be highly efficient over their operating life. This indicates the use of as high steam pressures and temperatures as can be justified for the turbine considered.

Steam generators are operating with natural circulation at pressures up to 2400 psi. Forced circulation and once-through steam generators will probably be used in new high pressure plants generally with one or more stages of reheat. These may cost less when the usual large steam drum can be omitted.

Steam pressures considerably above the critical pressure of 3206 psia have been used in several recent new plants. Such high pressures increase the cost of boiler feed pump, economizer, evaporating surfaces, superheater, steam piping and the forward end of the turbine. The increased power required by the boiler feed pump absorbs a large portion of the gain resulting from the increased pressure.

Metallurgical difficulties appear at present to limit steam temperatures to about 1100° F. Higher steam temperatures at a given pressure would increase the cost of the secondary superheater, the high pressure steam piping and the inlet section of the turbine. On the other hand the energy required by the boiler feed pump would be reduced for a given generator output. Such advantages over increased pressures should encourage the development of new metals of moderate cost which are capable of withstanding higher steam temperatures. From an efficiency standpoint higher steam temperatures are more desirable than higher pressures.

Limited gains in efficiency are possible at the low temperature portion of the thermal cycle. Flue gas temperatures to chimneys are generally about 300° F. Steam generator efficiency is improved about 1% for 35° F. reduction in flue gas temperature. A reduction to 160° F. would result in a 4% gain in overall station economy and at no added cost to plant equipment other than such low pressure equipment as is necessary to effect this reduction in flue gas temperature. This substantial gain in efficiency deserves consideration in new steam plant designs.

Combinations of gas and steam turbines have been proposed and certain of these proposals have shown possible gains in overall efficiency. Such combinations may be used where natural gas or oil serves as fuel. The main difficulty with such combined plants is the inability of present forms of gas turbines to effectively use coal as fuel. When gas turbines can burn coal satisfactorily, there may be a more extended use of the combination of steam and gas turbines, probably with pressurized boiler furnaces.

Pumped storage of water has been revived as a means of improving system economics. Off-peak energy supplied by large highly efficient steam turbine generators at a low increment cost of operation, would be used to pump water to elevated storage ponds. This stored water is discharged later through hydraulic turbines to carry peak loads which would otherwise require added steam plant capacity and additional fuel. Pumped storage has been used overseas for more than fifty years. In the United States, the Rocky River plant of the Connecticut Light & Power Co. has operated for 29 years. No other pumped storage plant was built until recently. In considering pumped storage, overall efficiency and increasing fuel costs must be carefully analyzed. Experience indicates an overall efficiency of such plants of 60 to 65% due to losses in transmission lines, transformers, motors, pumps, pipelines, reservoir seepage and evaporation and electrical generators. As a consequence, where off-peak energy from steam plants is contemplated for pumping, increased fuel prices may soon make pumped storage uneconomical.

Fuels

Natural gas is burned at present as a fuel in some power plants. Extensive pipe lines to distant cities and increasing gas costs at well head will make this luxury fuel too expensive to use for generating electricity except during summer off-peak periods for gas.

The future use of fuel oil in power plants is also questionable. Improved cracking methods at refineries reduce the proportional amount of residual or "Bunker C" oils which have formerly been sold to power plants at low cost. Such residual fuels contain all the impurities in the raw petroleum. The contents of sulphur and other impurities may be so high that its use will be prohibited in certain areas.

Atomic power plants are being built in increasing numbers. Some time must elapse before experience indicates which system leads to lowest total production cost of electrical energy. It is apparent that for the next twenty years, steam plants burning fossil fuels will predominate in extensions to electrical systems.

The ash content of commercial coal appears to be increasing due to strip mining, the use of mining machinery and the recovery of coal from seams of lower quality. Excess ash can be removed in some cases by washing. High ash contents increase the freight charges in shipping coal. The location of a steam plant adjacent to a coal field deserves consideration particularly when cooling water is available and where distances from plant to loads are not great. Increased transmission line voltages and freedom from increasing freight rates on fuel, may make such a location profitable particularly if lignites or other low heat value coal must be burned. Such locations would probably be free from restrictive ordinances governing smoke, sulphur and other gaseous discharges from chimneys. The disposal of ashes should cost little in mining areas.

Attention must be given to the combustion of sub-bituminous coal and lignite that are abundant in certain sections. These formerly were troublesome to burn due to the difficulties in maintaining capacity in winter with high moisture in the coal, snow, ice and low outdoor temperatures. It is possible to burn such fuel in pulverized form when primary air is preheated to at least 700° F. or where the fuel is predried before entering a pulverizer. In Germany, furnace gases are introduced directly into Kraemer mills. The practice of introducing furnace gases with their sparklers into present types of American pulverizers has an element of danger that should not be overlooked.

Disposal of ashes as fill may become a problem during the life of the plant. Cost of haulage could be a significant item of operating cost. Some ash may be worth examination as a source of rare metallic elements.

Communities are becoming conscious of discharges of dust and gases from chimneys. Tall chimneys are desirable to provide wide dispersion of the gases. Dispersion is further improved by high gas velocities from the top of the chimney secured by the use of one or more orifices. The development of some automatic means to maintain high exit velocities from the chimneys at all loads is highly desirable.

Automation

While certain advantages may be gained by the use of some steam-driven auxiliaries such as boiler feed pumps, these require additional piping and must have the attention of operators as they are generally less easy to operate from a control centre than motors. Electrically driven auxiliaries are favored where central controls are installed.

All plant operations are generally under full control of the man in charge of the control room. The few other men on shift move around the plant to note and remedy any mechanical or electrical defects. While the present operating staff is more highly trained and better paid than operators in earlier plants, this large reduction in personnel has been a factor in maintaining low production unit costs.

Controlled operation requires the use of sturdy and reliable instruments of many types and these are undergoing steady improvement. There is still a need for simplification in the control room and for the elimination of instruments which contribute little to operating efficiency. An instrument that would give instant and continuous indications of overall plant efficiency would be a desirable addition to ensure highest operating economy.

Plant details

Large coal bunkers that contained 30 hours or more of coal supply have been carried at the top of the boiler room by heavy steel framing. Bunkers of 10 to 12 hours capacity with duplicate conveyors to take coal from outdoor storage piles, seems a better arrangement. Dust from such storage piles in built-up localities must be prevented by oiling or other treatment.

Plant may be outdoor, semi-outdoor or enclosed, depending on climatic conditions. Where plants are enclosed, walls of sheeting or panels have largely replaced more expensive brick or concrete walls. Many power stations have few outside windows and depend on artificial lighting and ventilation.

Steam generators have large radiant furnaces and rise to considerable height above basement floors. This construction generally requires a long steam pipe from the superheater outlet to the steam turbine inlet. Higher steam pressures and temperatures increase both the cost of such piping and its length since liberal bends must be employed to care for expansion of the thick pipes. Evidently the design of steam generators should be modified to decrease the length of the high pressure steam piping. Several schemes have been suggested: to turn the furnace upside down and fire from the top; to make the secondary superheater of the radiant sidewall type with its outlet approximately at the level of the turbine inlet; or, when floor space is available, to build the boiler on its side. The last form would save steel and would seem fitting for units of the "once-through" type.

Pressurized furnaces have demonstrated certain advantages but present problems in building large units.

Improvements in the design of evaporators and the use of oversized units have resulted in satisfactory supplies of feed water in moderate pressure plants. Demineralizers can furnish feed water free from mineral and gaseous impurities as needed by the highest pressure steam generators. Such equipment has not been made fully automatic and an operator is generally required to check water conditions in demineralizer and steam generator and to care for the regeneration of the resins.

Hydrozine and other non-metallic compounds are used in high pressure and once-through steam generators to control alkalinity of the evaporating water, in place of the sodium compounds formerly used.

Superheat temperatures are controlled by spray desuperheaters, by attemperators, by combined radiant and convection surfaces, by changing burner pitch in the furnace and by gas recirculation. Spray desuperheaters require pure feed water for the sprays. Attemperation by partial condensation of the entering steam or by cooling the steam between primary and secondary superheaters by heat exchange to boiler water, has proven satisfactory. Combinations of radiant and convection surfaces produce relatively constant superheat over a wide range of load. Changing burner pitch varies superheat by altering gas temperatures at the superheater. Gas recirculation sustains superheat temperature at light loads.

Operating experiences indicate that much can be learned about heat transfer in superheater sections, the proportioning of superheater surfaces and the control of final superheat temperature. Panel forms of superheater tubes, widely used abroad, are proving satisfactory.

Tempering of air to the air preheater is a problem where extremely low winter temperatures are experienced. Steam preheaters have frozen. Recirculation of preheated air increases the input to the forced draft fan. Radiation loss from the steam generator is employed in one plant to temper incoming air. There is need for a better method to temper air.

The removal of ash particles from the flue gases becomes of increasing importance due to the increasing ash contents in coal and to more stringent regulations on chimney discharges. If equipment is provided to cool the flue gases to 160° F. as suggested above, the dust must be removed before the gases reach this equipment. This may require the development of an electro-static precipitator that can function satisfactorily in hot gases. The equipment to cool gases to 160° F. must be suitable for washing periodically while the plant is at capacity and also easily cleaned during an outage. No commercial method has been developed for the removal of sulphur and nitrogen compounds from the flue gases.

Attention must be given with large turbine generators to small gains that may be secured from drain coolers and from counterflow sections in high pressure extraction heaters to take advantage of the superheat in the extracted steam. Boiler feed pumps have been placed beyond the highest pressure heater so that pump losses can increase the temperature of the feed water to the economizer.

An economizer element serving as the section to cool the flue gases to 160° F. may replace the first extraction heater after leaving the condensate pump. This combination would increase overall station economy.

Various attempts are being made to reduce the pressure losses between the last blade row and the condenser tubes and also in the tube banks. Aluminum tubes and tube sheets are being tried with fresh water. Rates of condensation in the condenser may be increased and the total cooling surface reduced by increasing the water velocity in the tubes above 6 or 7 ft. per sec. as now used.

Steam jets to produce vacuum have efficiencies of only 5 to 7%. Small steam pipes, often with reducing valves, are required with these jets, and it is desirable with high pressures to eliminate such piping. Two-stage heaters must be supplied with the jets to recover the heat in the discharged steam. Modern high speed dry vacuum pumps have many times the efficiency of the steam jets, which reduces their energy demand on the station. Increasing fuel costs will make the consideration of dry vacuum pumps desirable as fuel savings can soon pay for the extra cost of these pumps.

Many different types of condensers are available with varying arrangements of tubes, steam paths and water flow. Consideration must be given in the selection of a condenser to operating problems connected with tube fouling, reverse water flow, air cooling, and the condensate pump.

There is the problem of the utilization of the heat in the exhaust, which at present is generally discharged to waste in the cooling water. One Canadian city used this heat to modulate the temperatures of its water supply in winter so as to prevent freezing of distribution lines. The condenser cooling water was used in an industrial plant for space heating by regulating the vacuum according to the outside temperature.

A German city used condenser cooling water in its public baths. Some method should be devised to use at least a portion of the 50% of the heat in the fuel that is now thrown away in condenser cooling water.

Air-cooled condensers have been suggested for certain locations with a small water supply. These become unusually large and it is difficult to maintain a reasonable vacuum in summer time.

Cooling towers will be used more extensively where water supplies are limited. Large ground areas are required so that towers may be widely spaced to prevent recirculation. Chimneys on cooling tower outlets aid in lessening recirculation. The *evasé* cooling towers used in Europe, are so tall that recirculation seldom occurs. They can be placed closer together than towers of the current American type.

Consideration must be given to the effect of thermal stresses in turbine parts when high steam temperatures are used. It is desirable to provide for quick start-up and for rapid load changes from system disturbances. These problems are increased with reheat. Double casings in the high temperature sections of the turbines lessen the difficulties with thermal stresses.

Fluid-cooled stator coils permit the construction of larger electrical generators. High hydrogen pressures are employed for rotor cooling. Motor generator exciters permit preheating of rotor and rotor windings before reaching operating speed. This practice has lessened failures of insulation on rotor windings.

These paragraphs present some of the factors that should be considered in the design of steam power plants. New developments are made and practice changes so that other considerations may become more important in future years.

DISCUSSION

WE WISH to thank all of the people who contributed to the discussion of this paper for the time they have taken and for the helpful criticism offered.

Since a number of points were raised several times by different people, we should like to change the manner of reply from the customary one by speaking to each issue raised, rather than to each commentator.

Ability of turbine to burn Bunker C and the economics involved in relation to other prime movers

For our experimental work we have used the Bunker C oil directly from tank cars without any treatment except heating and filtering to remove particles greater than .015″. We have been able to turn the oil off and on at will with positive relighting even at subzero temperatures. Operation of the power plant has so far been entirely on Canadian residuals, and we do not expect to have significant corrosion trouble with these at a combustion chamber temperature of 700°C. However, if one were to burn residuals high in vanadium and sodium such as are available from the South American or Middle East fields, it is possible that additive treatment would be required to prevent deposition at this temperature.

The suggestion has been made that diesel engines, and especially free piston gasifiers, are equally capable of burning Bunker C fuel. Experience on marine and railway diesel engines has indeed shown that Bunker C may be burned cleanly at full power, but the saving in fuel has generally been accompanied by a corresponding increase in trouble and maintenance, with the result that reduction in operating cost, if any, has not been established. It is probable that free piston engines will burn Bunker C fuel quite satisfactorily at full power; but it is not clear that satisfactory operation over a range of loads is possible, especially if some gas generators of a set are to be shut down as an economy procedure at light loads. It appears also that the maintenance costs of free piston engines will exhibit the same trends as the diesel engine. These are issues that need to be resolved before one may claim a saving from burning Bunker C fuel.

It has also been suggested that a free piston type of engine disposes of the combustion chamber problems sometimes associated with gas turbines. While it is true that the problem of burning Bunker C in a gas turbine is real, it is difficult to see how it has been disposed of in the free piston engine, where it is associated with smaller injection nozzles and finely machined and closely fitted mating surfaces, which are highly susceptible to dirt, carbon and sludge. In practice, severe oil contamination and a two or threefold increase in wear of piston rings and cylinders has been encountered when burning Bunker C in reciprocating engines.

Capital charges, maintenance and repairs

We have not compiled figures for the cost in quantity of the experimental power plant described herein; but in the design we have paid some attention to details which seem to us to be especially important in the reduction of capital and maintenance costs. In terms of both capital and maintenance costs, the purely rotating gas turbine seems likely to show a considerable margin of superiority over both the diesel and free piston types.

Reliability, control and flexibility

We agree entirely with the comments that a locomotive power plant capable of replacing present diesel units must be superior in reliability and convenience of operation, and that the flexibility of operation achieved by multiple working of diesel units is indeed very satisfactory. While the proposed gas turbine output appears at present to be a useful one, it is quite possible to scale this type of unit for either larger or smaller power.

Transmission

We agree that the high reduction ratio involved in gearing a turbine directly to the wheels involves problems during shunting, slipping, etc., but are satisfied that they can be managed in a practicable way. The proposed arrangement with a two stage traction turbine allows one to couple directly to the wheels without a gear change. The free piston gasifiers with the higher pressure and lower temperature gases ease the problem of gas ducting, but on the other hand make a five or six stage traction turbine necessary which because of its poorer torque-speed characteristic requires either gear changing or electric drive to give satisfactory train operation. In the arrangement proposed, the gear box and turbine are carried as sprung weight and are therefore not subject to the most severe rail shocks.

Thermal efficiency and cycle potential

The efficiency of 21% given in the report makes adequate allowances for pressure drops and is, we feel, realistic for the arrangement set out. This will be reduced further by a transmission gear loss to give a net efficiency at the rail of 19%. The diesel engine is often credited with a thermal efficiency of 32%; but, in practice, it achieves more nearly 28%. Applying to this a factor of 80% for electrical and gear losses one finds the comparable diesel efficiency is 22.4%. The published efficiency of the free piston engine is 40% as a gasifier and this is reduced to 32% after putting the gases through a turbine. If the arrangement is used with an electrical drive, the rail efficiency is only slightly better than that of the diesel. If it is used with a mechanical drive, one finds that the starting torque of the five or six stage turbine necessary for existing gas pressures is not sufficient for good train handling and a two speed transmission with its additional complication is then necessary.

It should be emphasized that the proposed cycle was not arrived at merely for reasons of efficiency, but on grounds of general adaptability, simplicity and inherent capability for development. By suitable choice of the three basic design quantities available (overall pressure ratio, maximum cycle temperature and boiler size or effectiveness) the emphasis can be shifted among overall thermal efficiency, machinery size and cost, maintenance requirements, water consumption, etc., with a large degree of freedom, the main restriction involving the need to maintain nimble starting characteristics so that the essential feature of low consumption idling is retained. From an economic point of view, the optimum power plant is that with the lowest total operating costs comprising fuel costs, maintenance costs and capital charges. The present power plant, with moderate temperature and pressure ratio, represents a considered starting point which may well be close to a present optimum and also serves to provide experience indicating the directions in which progress must be made to reduce the total running costs to a minimum. As an example of the diversity of possibilities, an increase of maximum cycle temperature from the present level to 1000°C. may be utilized in at least three ways. Firstly without prejudice to the existing level of economy, the arrangement can be considerably simplified by the elimination of the entire low pressure compressor gas turbine system with considerable benefit to capital costs. Alternatively, both the present level of efficiency and pressure ratio may be maintained but the boiler considerably reduced in size with the resulting water consumption less than half the present level. Finally, the overall pressure ratio can be increased to 8:1 with the overall thermal efficiency increasing to values in excess of 30% and a resultant efficiency at the rail considerably greater than that possible from either the diesel or the free piston gasifier units as presently envisaged. In going to 1000°C. one could, for example, employ water spray cooling on the turbine blades which, in addition to improving the performance, could also afford protection against blade fouling and corrosion.

The fall off in power of the gas turbine as the ambient temperature rises is, of course, more pronounced than is the case in the diesel engine, but the corresponding increase in turbine power with a drop in ambient temperature seems to be the really significant feature because of the general railway requirement for increased powers in cold weather.

Starting from cold

The one hour starting time referred to in the report is for a completely cold engine and would be about the same for summer or winter conditions. While this is an appreciable time, the certainty of securing a start is inherent, a respect in which it invites comparison with either the diesel or the free piston engine under winter conditions. When the engine is in a roundhouse with steam available, the time required to bring the unit to low idle condition should be greatly reduced. From the low idle condition, the power plant is found to be very responsive and will give a performance in standing fuel costs, and time to full load about the equal of the diesel engine.

Dynamic brakes

In the report we have made no reference to dynamic brakes which have been found very useful in some regions but of little value in others. We have in mind an arrangement for dynamic braking using a water brake coupled directly to the traction turbines.

Simplicity

Mechanically the arrangement is clean. The use of a separate steam turbine is, we believe, an advantage which incidentally disposes of electrical energy storage and the use of direct current. Blowing the steam into the main gas turbine would eliminate one shaft, but would deny one of the benefits obtained from a two shaft machine. These appear to us to be considerable, particularly from the aspects of control and part load operation. There would also be an additional boiler corrosion hazard if one were to blow the wet exhaust gases through it.

Coal burning locomotive

The possibility of burning coal in a gas turbine locomotive is an intriguing concept but in practice is a much more difficult task than burning Bunker C. In addition to the problem of supplying fuel and avoiding erosion and corrosion problems, there is the added difficulty of "control" with a suitable response. For these reasons we believe the burning of coal in a locomotive can most advantageously come after some measure of success has been attained with oil fired machinery.

Water consumption

It is appreciated by the authors that the relatively large water consumption is an embarrassment, but the advantages accruing from the system proposed seemed to us worth the price. It is in fact this feature which differentiates between this proposal and a large number of others.

The boiler has sufficient capacity to supply the 6000 lb./hr. of steam for train heat in addition to the compressor work, and a pressure of 250 p.s.i. as suggested is practicable although we have chosen 150 p.s.i. with more superheat as being preferable for the engine itself.

We appreciate very much the suggestion that, with the rate of water consumption we have proposed, a tender supply of 10,000 gallons would ensure uninterrupted running over a railway division. While we foresee ways of reducing water consumption to a fraction of that now proposed (with elimination of the tender or extension of running to several divisions), we again draw attention to the special advantage of certain uses of steam. Apart from the questions of efficiency and fast starting set out in the paper, there are a number of other important implications. The storage and generation of starting energy as steam eliminates entirely the need for storage batteries, controls and a d-c. electrical system. The use of three phase alternating current with standard industrial squirrel cage motors seems to us to be an important advance in reliability, simplicity and cost.

THE INTERCONNECTED POWER SYSTEMS OF NOVA SCOTIA AND NEW BRUNSWICK

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THE INTERCONNECTION of the electrical power systems of Nova Scotia and New Brunswick is expected to be accomplished by March 1960. Participating utilities are the New Brunswick Electric Power Commission, the Nova Scotia Power Commission, and the Nova Scotia Light & Power Company Limited. The interconnection involves the construction of 105 miles of single circuit 138 kv. transmission line and the expansion and modernization of five substations, together with necessary relaying, metering, carrier control and communication equipment.

Fig. 1 shows the general service areas of the participants. The area served by the Nova Scotia Power Commission is divided by that of the Nova Scotia Light & Power Company. The New Brunswick Electric Power Commission is separated from the Nova Scotia Power Commission by the service area of the Canada Electric Company. For the purpose of the interconnection, the Canada Electric Company is considered as part of the Nova Scotia Power Commission's system. These two utilities have had an interconnection for some years and it is felt that this additional expansion can be more conveniently handled by one utility. Included within the interconnection agreement will be roughly 67% of the generating facilities of the two provinces. Private industry, municipalities, the Seaboard Power Corporation in Cape Breton and the Gatineau Power Company in northern New Brunswick supply the remainder.

The three participants are practically equal in size and their loads are approximately the same. At the present time the loads of both the Nova Scotia Light & Power Company and the New Brunswick Electric Power Commission are increasing at a somewhat greater rate than the load of the Nova Scotia Power Commission.

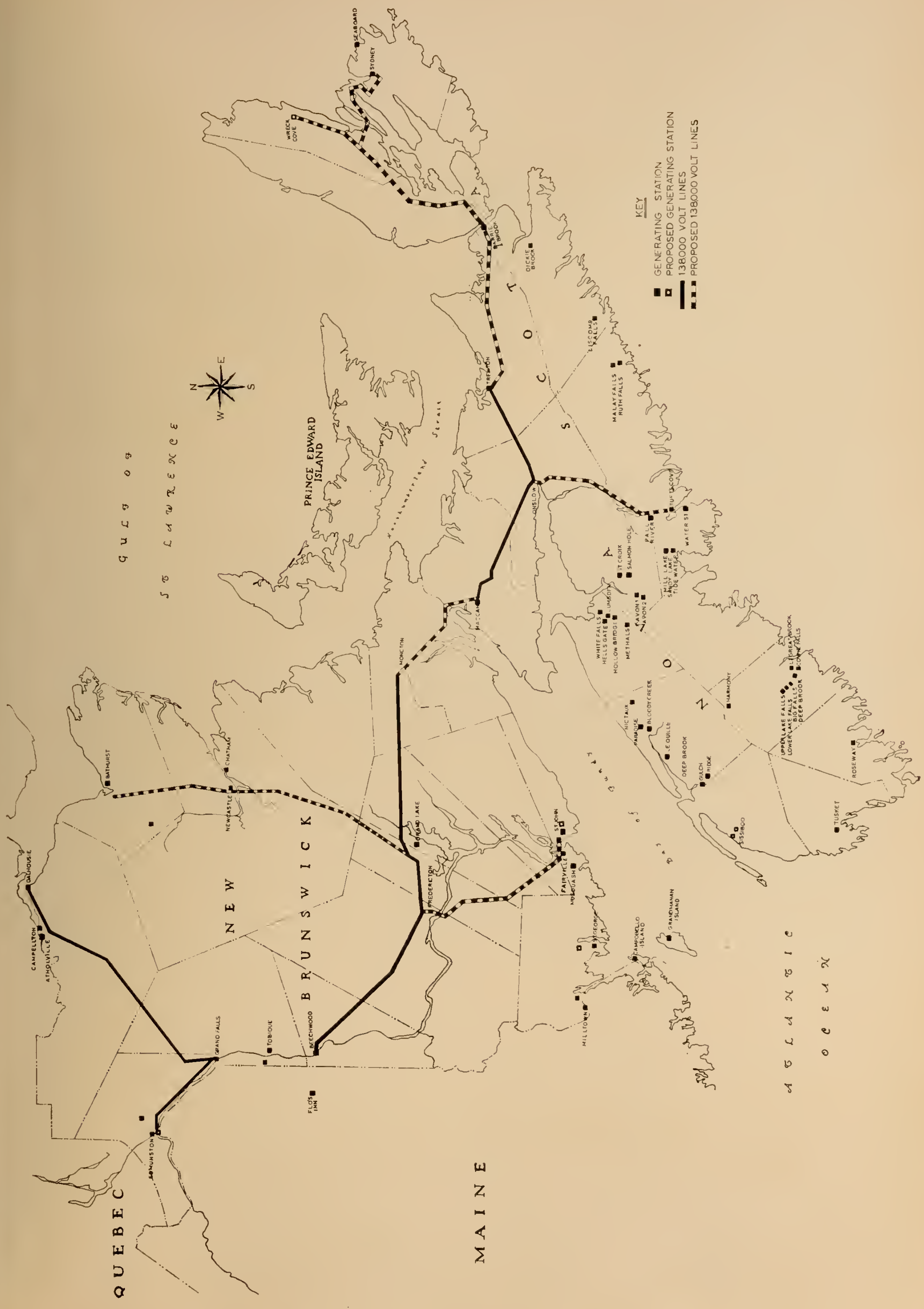
The interconnection of two or more generating systems always reduces the amount of generating capacity to be installed as compared with that which would be required without the interconnection. The amount of such reduction may be small or large depending on the interrelation of the various factors and characteristics of the interconnecting systems and the level of service reliability. The installation of the transmission facilities that are necessary to bring about the interconnection may or may not be justified. This fact can be determined only by a proper economic comparison of the alternate installation.

In May of 1957, engineers from the three participating utilities, together with other interested parties, conducted a series of loadflow studies on the Westinghouse a-c Network Calculator at Pittsburg to check performance of the interconnected systems and to get an indication of conductor size and voltage level requirements of the tie lines. These studies clearly indicated the interconnection technically feasible.

Subsequently, management set up an engineering committee composed of staff of all three utilities for the express purpose of determining the economics of the interconnection. From the data obtained at the Pittsburg studies, capital expenditure for tie lines, substations and related equipment was estimated at $4 million. It remained to be shown what capital savings could be effected because of reduced reserve requirements under interconnected operation.

Probability theorems were used to compare the reserve position of each utility with that of the proposed interconnected system for varying degrees of service reliability. This approach was necessary because none of the participating utilities had identical reserve policies. To compare the capacity required of one utility to carry out its load responsibility with the same degree of reliability as another would otherwise have been difficult.

Partial results of this study are shown in figs. 2 and 3. Fig. 2 is computed for a service reliability of


QUEBEC
NEW BRUNSWICK
MAINE
NOVA SCOTIA
PRINCE EDWARD ISLAND
GULF OF ST LAWRENCE
ATLANTIC OCEAN
KEY
GENERATING STATION
PROPOSED GENERATING STATION
138000 VOLT LINES
PROPOSED 138000 VOLT LINES

one day in five years, that is to say, with the amount of capacity shown there is a probability of not being able to carry the load (all or any part of it) of one day in five years or an outage probability of 0.2 days per year. Results for the four years, 1959 to 1962, are shown. Other years will be similar. Fig. 3 is plotted for the year 1961. The ordinate represents the probability of failure in days per year while the abscissa shows the installed capacity in megawatts. Note that as the reliability is increased (or the probability of outage is decreased) the installed capacity for separate operation increases at a far greater rate than that for interconnected operation, e.g., with a peak load on the system of 490 mw. and a reliability level of one day in five years, the interconnected system would require 52 mw. of reserve capacity. If, however, the utilities operated independently they would require a total of 224 mw. or roughly 4 1/3 times as much.

Fig. 1. Interconnected Utilities — areas served by generation.

The results of the study shown graphically in fig. 2 can be tabulated as in table I.

Estimating the capital cost of interconnecting existing facilities as $4 million and annual carrying charges as 7%; and the capital cost of capacity as $150 per kw. and annual carrying charges as 8%; then the annual dollar benefit is as shown in Table II.

Another result of this study was to show that on an interconnected basis, a reserve of approximately 12% of system peak would be required for an acceptable degree of service reliability. All three utilities have been carrying reserve approximately 30 to 40% of their peak loads because of established reserve policies.

After due consideration of the results of this study, the three utilities mutually agreed to proceed with the interconnection and directed the engineering committee to complete design of interconnection facilities. At the same time an operating committee was appointed to draft a suitable interconnection agreement.

Of necessity there has been close liaison between the engineering and operating committees. It was agreed in early discussion that the main purpose of the tie transmissions would be to supply reserve power between utilities in case of emergency. It was recognized that firm power interchange would in all probability require double circuit 220 kv. transmission which would nullify the economic benefits of the interconnection, at least at the present time. It was decided that in general the capacity installation of any utility would not be permitted to fall below the peak load of that utility. For this reason tie line flows would be restricted to a maximum of about the capacity of the largest unit on the system at the time.

The design of the interconnecting facilities was well advanced early in 1958. Final decision on conductor size and voltage level was withheld however, and no equipment orders were placed pending confirmation of the results of our studies by another network analysis which was undertaken in April of last year.

This study resulted in the final choice of a 138 kv tie line using a 556,600 circular mill ACSR conductor. Transformer types, sizes and tap range were established along with circuit breaker ratings, stability limitations and reactive requirements.

Loadflow studies were carried out to check operation on a maximum transfer of 100,000 kw. either from Nova Scotia to New Brunswick or vice-versa. This transfer appeared possible under emergency conditions; normal operating conditions may be lower than this level for some time.

Loadflows were also checked to provide operational data such as voltage levels, var flows and system losses.

The systems were checked for both steady state and transient stability in accordance with the best advice available regarding critical points of the interconnection. No particular technical problems were encountered.

The Engineering Committee have now decided on a uniform design for the entire interconnection. It is to be a steel tower line with double overhead ground wires and counterpoise where necessary. Power line carrier communication with provisions for

Table I

Year	*Estimated Combined Load*	*Capacity Separate System*	*Capacity Connected System*	*Capacity Benefit*
1959	398	539	449	90
1960	444	624	495	129
1961	490	714	542	172
1962	541	772	606	166

Table II

Year	*Capacity*	*Interconnection*	*Benefit*
1959	$1,080,000	$280,000	$ 800,000
1960	1,548,000	280,000	1,268,000
1961	2,064,000	280,000	1,784,000
1962	1,992,000	280,000	1,712,000

relaying, telemetering and supervisory control has been chosen for the entire link.

The choice of 138 kv. for tie line voltage was indeed a fortunate one since both the Nova Scotia Power Commission and the New Brunswick Electric Power Commission had some 138 kv. lines either under construction or in operation before decision was reached to interconnect. The Nova Scotia Power Commission had the section of line from Trenton to Onslow and from Onslow to Maccan constructed for 138 kv. but operating at 69 kv., while the New Brunswick Electric Power Commission had a considerable amount of their 69 kv. grid overlaid with 138 kv. transmission.

The three utilities have now all accepted in principle the agreement submitted by the operating committee. This agreement provides for the seting up of an administrative committee composed of one representative of each utility to: (a) Interpret the provisions of the agreement, (b) Consider load forecasts and schedule generation. (c) Supervise the operating committee.

The operating committee will be composed of one representative and an alternate from each utility and will be responsible for: (a) Scheduling of daily spinning reserve and daily placing of orders, (b) Scheduling maintenance, etc.

It is anticipated that the systems will always be operated in parallel and that a plan will be set up for frequency regulation. Kilowatt hours will be exchanged on a scheduled basis only, and spinning reserve will be allocated between the parties.

Reserve capacity limits for the interconnection have been established between a minimum of 10% and as close to a maximum of 15% as practicable. Each utility will be required to contribute a reserve capacity equal to its peak load times the percent reserve determined as adequate for pool operation or pay at the rate established in the Agreement to others carrying it. At the time a new unit is to be installed to retain the desired system reserve ratio, it will be the responsibility of the participant having the lowest reserve ratio at that time to install the necessary unit. Many alternate patterns of installation are possible under the terms of the agreement. Naturally any pattern will be under continuing review and adjusted as actual load conditions deviate from those forecast.

Peak loads shown are outgoing feeder peaks and installed capacity

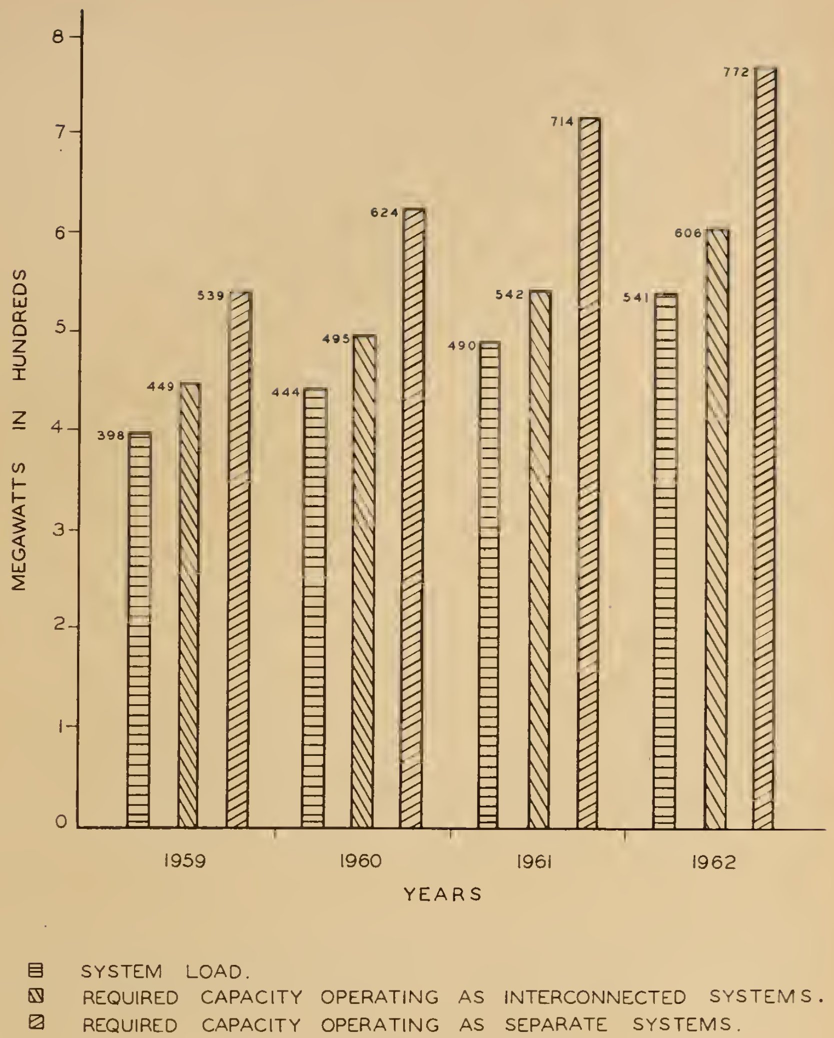


Fig. 2. System load vs. installed capacity.

Table III

	Load (Peak)				*Installed Cap.*				*Reserve MW*				*Reserve %*			
	NB	*NS*	*NSL*	*Ttl.*	*NB*	*NS*	*NSL*	*Ttl*	*NB*	*NS*	*NSL*	*Ttl.*	*NB*	*NS*	*NSL*	*Ttl.*
1959	154	120	146	420	196	152	225	573	42	32	79	153	27.3	26.6	54.1	36.4
1960	171	130	164	465	196	167(a)	225	588	25	37	61	123	14.6	28.5	37.2	26.5
1961	188	140	184	512	243(b)	167	225	635	55	27	41	123	29.3	19.3	22.3	24.0
1962	206	151	206	563	243	173(c)	234(d)	650	37	22	28	87	18.0	14.6	13.6	15.5
1963	226	163	230	619	243	247(e)	234	724	17	84	4	105	7.5	51.5	1.7	17.0
1964	246	176	258	680	243	253(f)	304(g)	800	—3	77	46	120	—1.2	43.8	17.8	17.6
1965	270	190	289	749	313(h)	253	304	870	43	63	15	121	15.9	33.2	5.2	16.2
1966	295	205	324	824	313	261(j)	390(k)	964	18	56	66	140	6.1	27.3	20.4	17.0
1967	322	221	363	906	407(l)	261	390	1058	85	40	27	152	26.4	18.1	7.4	16.8
1968	353	239	407	999	407	261	484(m)	1152	54	22	77	153	15.3	9.2	18.9	15.3
1969	385	258	456	1099	407	355(n)	484	1246	22	97	28	147	5.7	37.6	6.1	13.4
1970	420	279	511	1210	501(p)	355	484	1340	81	76	—27	130	19.3	27.2	—5.3	10.7

N.B.—New Brunswick Electric Power Commission.
NS—Nova Scotia Power Commission and Canada Electric Company Limited.
NSL—Nova Scotia Light and Power Company Limited.

represents net capacity after allowing for station service. It will be noted that for the three years 1959-61 system reserve is considerably above that which is necessary. This is because certain unit installations were committed before agreement to interconnect was reached. A condition of the agreement provides that no deficiency payments shall be made between parties unless or until the system reserve ratio drops below 15% or the reserve ratio of an individual utility drops below 10%. This would happen in 1962 if new capacity is not added at that time. From this year onward, utilities having a reserve percentage lower than the system reserve percentage will pay capacity deficiency payments to the utility or utilities having a greater than system percentage reserve.

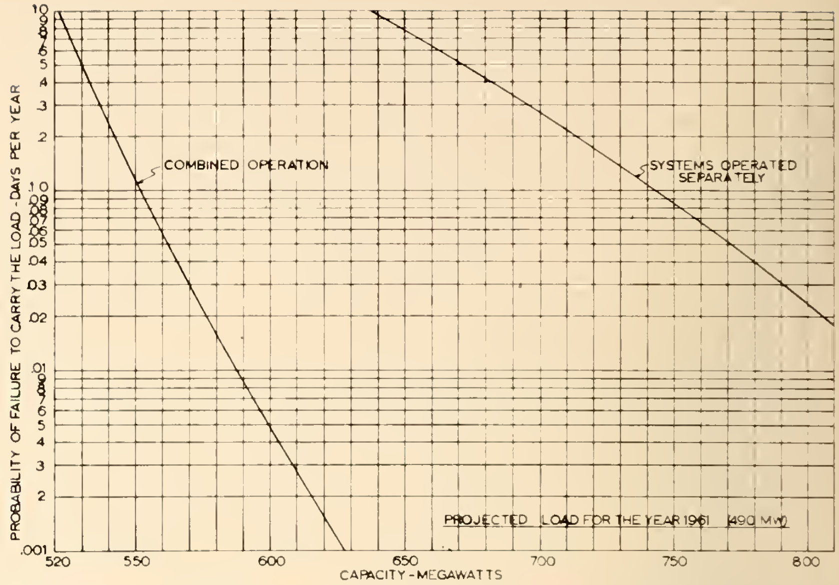


Fig. 3. Probable average frequency of occurrence of failure to carry the load for the year 1961.

The largest size thermal units at present operating in either Nova Scotia or New Brunswick are 50 mw. installations. The Nova Scotia Light & Power Company have two of these installed in their Water Street plant. The New Brunswick Electric Power Commission's Saint John plant will have a 50 mw. machine operating in 1961. The interconnection makes it possible, as well as economical, to bring into service in 1963 75 mw. units and in 1966 100 mw. units, which we feel would not have been advantageous with separate operation. It is interesting to note that decision to interconnect has already permitted deferment of additional units at Trenton and Tuft's Cove.

It is felt that the capital savings alone are sufficient to justify the interconnection. Other benefits come from the installation of larger units of better efficiency, exchange of surplus energy, and the opportunity of being able to postpone the installation of a new unit by purchasing a share in a large unit of a neighboring utility. This unit participation scheme could become one of the more valuable sections of the interconnection.

Possible future members of the interconnection could be the Seaboard Power Corporation in Cape Breton and the Gatineau Power Company in northern New Brunswick. Both of these organizations, although not as large as the three participating utilities, supply a substantial portion of the Maritimes load, and besides benefiting the interconnected system, should gain from it.

There exists at present a tie between the New Brunswick Electric Power Commission plant at Beechwood and the Flo's Inn Substation (Presque Isle) of Maine Public Service Company. The New Brunswick Electric Power Commission also has a number of ties in the northern part of the province with the different paper companies in that area. Both utilities in Nova Scotia have similar but smaller ties with industry and municipalities. Possible ties in the future may be with Prince Edward Island and through the New Brunswick Electric Power Commission to various utilities in Maine and Quebec.

New developments in the near future are a thermal station at East Saint John for the New Brunswick Electric Power Commission, one at Tuft's Cove (near Halifax) for the Nova Scotia Light & Power Company and a 74 mw. hydro installation at Wreck Cove (in northern Cape Breton) for the Nova Scotia Power Commission.

To sum up, we must say that we expect to derive greater benefits from the interconnection as it progresses and as the participating utilities become more familiar with the savings to be gained from one system operation. This of course will only come with the passing of years during which the individual participants will become more accustomed to group operation. We think that the savings and benefits derived from the first few years of operation will enable the participating utilities to see the advantages that can be theirs with a spirit of cooperation. We shall be able to achieve the savings of large system operation while retaining our independence.

As the load in the Maritimes increases so will the value of the interconnection, and we trust that this is only the first step toward better and cheaper power production in the Atlantic Provinces.

Table IV

Pattern of Net Installation for Table III

(a)	NSPC	15 mw.	Sissiboo	Hydro
(b)	NBEPC	47 mw.	St. John	Thermal
(c)	NSPC	6 mw.	Sissiboo	Hydro
(d)	NSL&P	9 mw.	Alpina and LeQuille	Hydro
(e)	NSPC	74 mw.	Wreck Cove	Hydro
(f)	NSPC	6 mw.	Sissiboo	Hydro
(g)	NSL&P	70 mw.	Tufts Cove	Thermal
(h)	NBEPC	70 mw.	St. John	Thermal
(j)	NSPC	8 mw.*	St. Margaret's	Hydro
(k)	NSL&P	94 mw.	Tufts Cove	Thermal
		—8	St. Margaret's	Hydro
(l)	NBEPC	94 mw.	St. John	Thermal
(m)	NSL&P	94 mw.	Tufts Cove	Thermal
(n)	NSPC	94 mw.	Trenton	Thermal
(p)	NBEPC	94 mw.	St. John	Thermal

*Return from NSL&P

WHITEDOG FALLS AND CARIBOU FALLS GENERATING STATIONS

Hydro-Electric Developments on the Winnipeg and English Rivers

N. S. Haines, M.E.I.C., *Project Engineer*
The Hydro-Electric Power Commission of Ontario

TO MEET the increasing demand for power in its Northwestern Region as in all sections of the Province, it has been necessary for the Ontario Hydro to maintain a continuous program of development of new power sites. The following is a description of the development of two of these sites—Whitedog Falls on the Winnipeg River and Caribou Falls on the English River, which were constructed as a combined operation. The construction of Whitedog Falls Generating Station was authorized on August 8, 1955. Eight months later it became apparent that still more power would be required shortly to meet the anticipated demand, and the construction of Caribou Falls Generating Station on the English River was authorized.

In Ontario, the two main branches of the Winnipeg River are the Winnipeg flowing northwest from the chain of lakes that forms the boundary between Canada and the United States immediately west of the Great Lakes, and the English flowing from the northeast. Tetu Lake at the confluence of the two tributaries is the common tailwater of both the stations described. The combined outflow from Tetu Lake passes over Boundary Falls and continues as the Winnipeg River, emptying into Lake Winnipeg. The provincial boundary lies one mile below Boundary Falls. Downstream from Boundary Falls through Manitoba to Lake Winnipeg, the total head of about 256 ft. has been fully developed in six plants, each with an installed capacity to use about 30,000 cu. ft. per sec. (see Fig. 1).

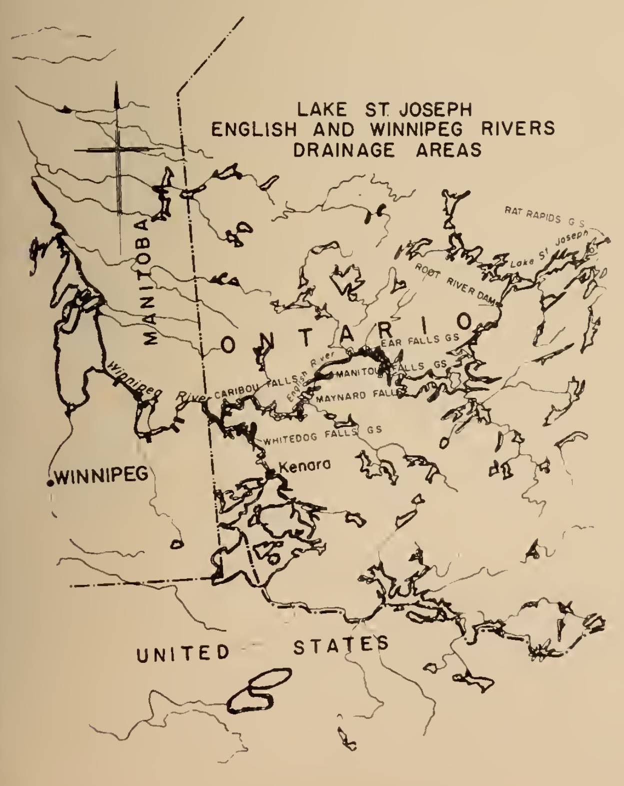


Fig. 1. Drainage area Winnipeg River.

Whitedog Falls is 17 miles north of Minaki, which is on the main line of the Canadian National Railway. The rated head is 50 ft. and the rated capacity 81,000 b.h.p. Caribou Falls is 17 miles farther to the northwest and has a rated head of 58 ft. and a rated capacity of 102,000 b.h.p.

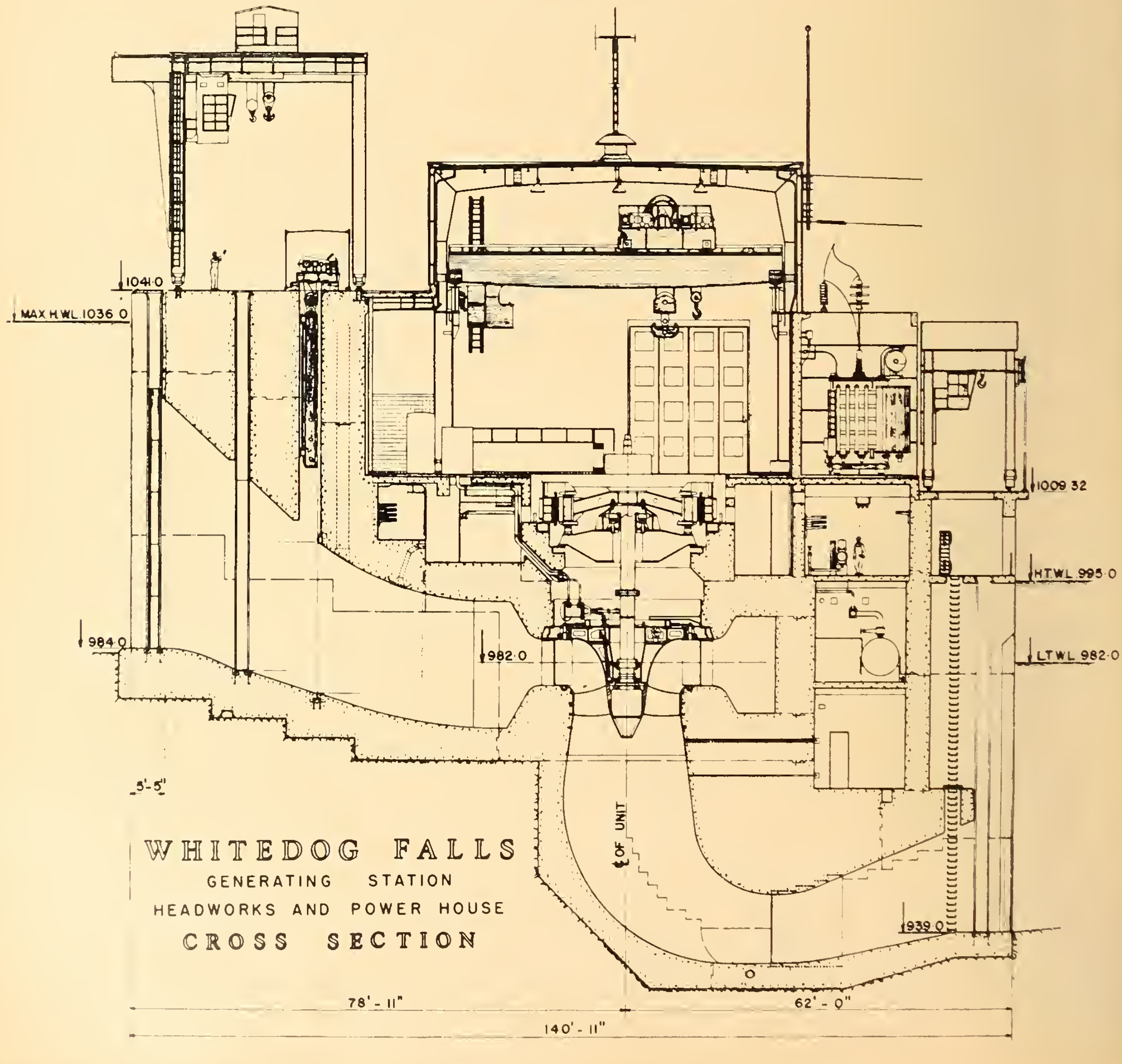
The Lake of the Woods, from which the Winnipeg River issues at Kenora, is an international lake, and its outflow is regulated by a control dam and four privately owned power plants. Under normal conditions responsibility for the lake levels and discharge is vested in the Canadian Lake of the Woods Control Board. Under conditions of extreme high or low water, this responsibility reverts to The International Lake of the Woods Control Board. The control works have a maximum discharge capacity of 50,000 cu. ft. per sec. and provide 4,990,000 acre-ft. of storage. The total fall in the Winnipeg River from below the Norman Dam at Kenora to the foot of Boundary Falls is about 54 ft.

Lac Seul, from which the English River issues at Ear Falls, is regulated by a control dam at its outlet. Responsibility for the regulation of Lac Seul is vested in the Lake of the Woods Control Board. This lake provides 4,530,000 acre-ft. of storage. Ontario Hydro operates the Ear Falls Generating Station at the control dam and about 20 miles downstream is located the recently constructed Manitou Falls Generating Station. The total fall in the English River from the tailrace at Manitou Falls to the foot of Boundary Falls is approximately 94 ft. This fall occurs as a series of rapids in the river section between intervening lake areas.

Preliminary Investigation

The original surveys of the various sites on the English River between Boundary Falls and Lac Seul were conducted by the Manitoba Hydrographic Surveys under the direction of the late M. C. Hendry, MEIC. In 1930 the Ontario Hydro and Dominion Government survey agencies expanded this information and secured topographic information on the Winnipeg River from Boundary Falls to Kenora. In 1951 an extensive survey was made of the Boundary Falls site to use the combined flow of both rivers in one plant under a head of about 50 ft. Studies made using this information indicated that development of Boundary Falls would be costly due to the extensive side dams and the clearing of large areas that would be flooded. The improved reliability of remote-controlled stations, with the resulting savings in colony costs that occurred at this time, now favoured the construction of multi-stage developments. In 1953 a survey of the upstream sites was undertaken to establish the best pattern for the development of the rivers. The pattern finally selected was to develop the full remaining head on the Winnipeg River at Whitedog Falls, the headpond of this plant to flood back to the tailwater level of the plants at Kenora. Since the tailwater of Whitedog Falls would be Tetu Lake, it was proposed to utilize the total fall by making channel improvements at Boundary Falls that would lower Tetu Lake. The pattern chosen for the English River was to develop 58 ft. of head at Caribou Falls site, which would also benefit from the channel improvements at Boundary Falls, and develop at some future date the re-

Fig. 2. Section Whitedog Falls powerhouse.



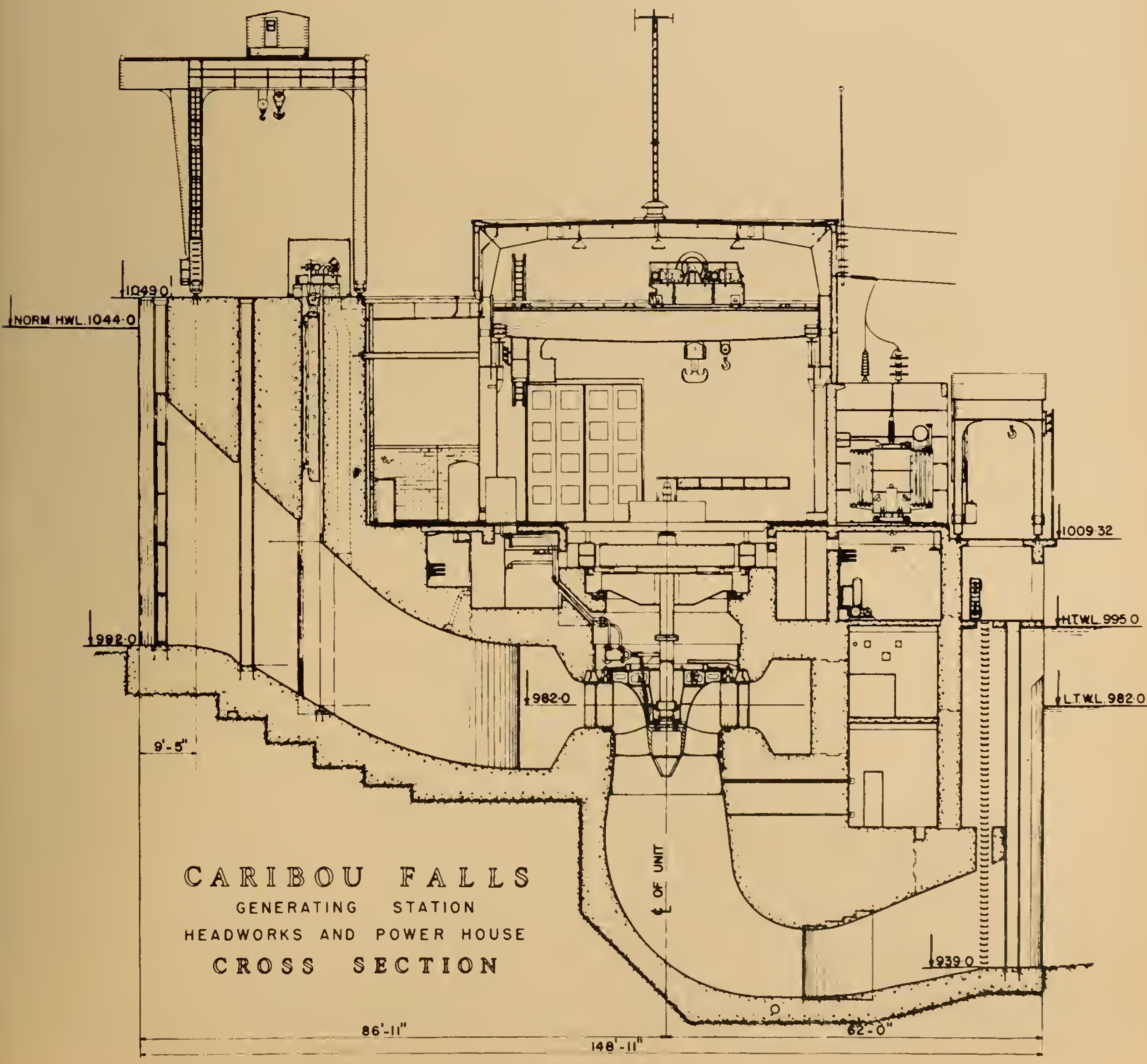
maining 36 ft. of fall on the English River at Maynard Falls.

Turbine Selection

The Northwestern System of the Ontario Hydro is not connected with the systems in the other section in the Province, but it is interconnected with the Manitoba Electric System, which contains both hydraulic and thermal stations, and thermal stations for the Northwestern Region were being considered. These conditions indicated that a low load factor plant would be advisable at Whitedog Falls. Also of a total drainage area of 27,170 sq. miles on the Winnipeg River, all but about 1,000 sq. miles were above the Lake of the Woods control dam, which has a storage volume of 184 acre-ft. per sq. mile of drainage area. The shape of the duration curve could therefore be varied to suit many conditions. The flow required on weekdays by the plants at the outlet of Lake of the Woods is constant, with the shutdowns during week-ends. The Whitedog headpond has an area of 33,000 acres, but since part of it is in a highly developed summer resort area, riparian owners would object to large fluctuations of water level. The present rule curve used by the Lake of the Woods Control Board produces a duration curve that would indicate an installed capacity to use a flow of 14,000 c.f.s. at Whitedog Falls at 60% load factor. An economic study showed that the incremental energy cost equalled that of thermal energy when the installed capacity uses a flow of between 16,000 and 17,000 c.f.s. The selection of this capacity was based on a duration curve of the Winnipeg River regulated for the maximum energy output such as might be desired when Ontario and Manitoba have developed substantial thermal-electric capacity. The studies indicated the economic limit of installation to occur with a maximum turbine discharge equal to the flow available 25% of the time. Under 50 ft. of head and at 88% efficiency, this gave a turbine output of approximately 81,000 b.h.p.

Maintenance conditions of a remote-controlled station such as Whitedog would indicate a smaller number of large turbines. Operating flexibility for maximum efficiency with varying flow conditions indicates a larger number of smaller

Fig. 3. Caribou Falls powerhouse section.



units. Five units similar to those previously installed at the Commission's Manitou Falls plant would meet the latter condition. The power was urgently needed, and units of this size could be procured without allowing much time for engineering and tests. On the other hand, the large number of units would require a longer installation period. Turbines of a size to develop this power under 50 ft. of head in one or two units were not in common use and considerable time would be required for engineering and model tests. A compromise was made and three units of 27,000 b.h.p. were decided upon. These units would have hydraulic characteristics similar to those at Manitou Falls and a physical size approximating the units at the Chenaux Generating Station built in 1950. It was known that such units could be procured within a reasonable time and preliminary estimates indicated some saving in cost as compared with a five-unit plant. The three turbines as purchased for the Whitedog Falls Generating Station were rated at 27,000 b.h.p. under 50 ft. head and at a synchronous speed of 105.9 r.p.m. Under these conditions the guaranteed efficiency was 90.3% and the discharge per unit 5,200 c.f.s.

Fig. 4. Whitedog Falls first stage unwatering.

Preliminary studies for Caribou Falls using similar basis and a duration curve for the English River indicated the use of two 46,500 b.h.p. units. To make the most efficient use of the water, Kaplan type turbines were considered. A further increase in the anticipated demand for power made the diversion of an average of 2,800 c.f.s. from the Albany River watershed to the English River desirable. This water would develop an additional 250,400,000 kwh. annually in plants already constructed on the English River or under active consideration. This increase in flow of 2,800 c.f.s. made the economic capacity of Caribou Falls larger, and three units of somewhat smaller individual capacity now appeared more appropriate. With three units and a large headpond it was felt that there was sufficient operating flexibility to use the water efficiently in fixed-blade turbines. Also an additional transmission line was being added to the Northwestern System, which would reduce the percentage of time that Caribou Falls Generating Station would be used for tie line load regulation. Kaplan type turbines were more expensive and the delivery time would be longer than for the fixed-blade type. The capacity chosen for the plant was 102,000 b.h.p. developed in three propeller type turbines at 34,000 b.h.p. each, under 58 ft. of head, with a synchronous speed of 112.5 r.p.m. and a discharge of 6,250 c.f.s. per unit. A duration curve prepared from English River flows plus the diversion from the Albany shows flow for this capacity to be available 25% of the time.

Similar units to those supplied for Whitedog Falls were provided, adjustments being made for the greater head and output. This proved to be a great saving in time and money as the turbines could be delivered within a minimum time and numerous parts were interchangeable between the two plants. Since the water passages and spacings were the same, the substructure drawings for Whitedog Falls could be revised and used for Caribou Falls (see Figs. 2 and 3).

The turbine analysis for both plants was based on synchronous speeds and settings which will allow operation under full gate without limitation of turbine capacity on account of cavitation restrictions at either rated head or maximum head. A band on the back or under side of the blades extending 24 in. in from the periphery was required to be coated with 1/8 to 3/16 in. of stainless steel as a further precaution against cavitation.

For both plants the generator capacity was based on the expected maximum output of the turbine rather than on a normal output of the machine based on its nominal rated capacity. The generator capacity chosen was such that when the turbine operates at maximum expected output, the generator will be operating at 10% over-rated capacity. The

Fig. 5. Whitedog Falls second stage unwatering.

transformer capacity was based on maximum turbine output less losses to the output side of the transformer.

Whitedog Falls Site

Above Whitedog Falls the Winnipeg River divided into two channels forming Whitedog Island. The north channel was small and under normal flows carried about 10% of the flow. The drop in this channel occurred as a series of rapids. The south channel, which carried most of the flow, passed through several rapids and swifts with the main pitch near the downstream end of Whitedog Island. The surveys undertaken in 1953 indicated two possible sites for the dam line. One site was at the extreme downstream point of the island, and the other slightly upstream at the foot of the main falls. On May 16, 1955, detailed surveys were commenced. The sites were investigated on a comparative basis by geological mapping, a seismic geophysical survey, and a limited amount of diamond drilling. Estimates were made as this information was received, while the investigation was in progress. These estimates favoured construction at the upstream site. The surveys and geological investigation were then concentrated on this site during the late summer and fall of 1955. The sites of two block dams required were also investigated; one at the head of the north channel, the other in a draw on Whitedog Island.

The overburden in the area consisted of alluvial clay overlying granular soils. The clay is more or less continuous except at points along the river bank or along flanks of rock outcrops where granular soils are sometimes exposed.

The underlying granitic type bedrock was exposed in the river channel and on both banks. Many surface slab fractures occurred but diamond drilling showed these did not extend to depth. The diamond drilling revealed that two zones of altered and fractured rock crossed the proposed dam line and these zones would require grouting. The altered zones were tight at greater depth.

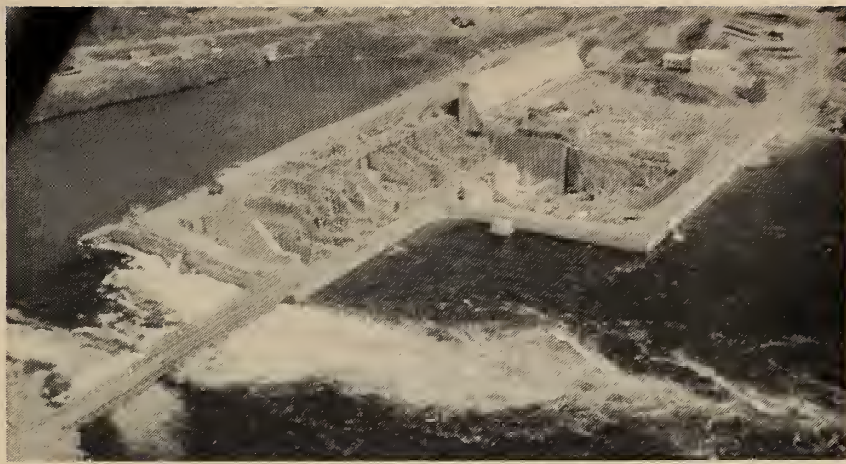


Fig. 6. Caribou Falls first stage unwatering.

Caribou Falls Site

Caribou Falls is located 8 miles east of the Manitoba border at the outlet of Umfreville Lake, which forms the headpond, and just upstream from Tetu Lake. The surveys of 1953 had indicated two possible dam lines at this site. One site was a short distance above the falls and the other was along the crest of the falls. Sufficient topographical and geological information was taken during the summer of 1955 to make comparative estimates of the two possible sites.

On the upper line granitic rock was exposed on the right bank and continued under the river. On the left bank outcrops of sedimentary gneisses were exposed, thinly overlain in places by shallow deposits of coarse brown sand formed by weathering of the rock. At the line along the crest of the falls the granite was exposed on the right bank and in the river section. The left bank was overburden composed of sandy silt overlain by a buff clay. This overburden extended back from the river about 1,000 ft., where there was a granite knob outcropping. A saddle between this outcrop and the gneiss outcrop on the upper dam line was filled with overburden and was possibly an old river channel. Estimates indicated the lower line along the crest of the falls to be the most economical. Further geological and topographical information was taken during the early summer of 1956 on the chosen dam line and on the sites of four block dams required. All the block dams were in rock saddles partly filled with the overburden typical of the area, that is, firm buff clay overlying dry sandy silt with perched water tables lying on the top of the clay, the top layer of which had a high organic content. Two of the block dams were on the right bank some distance from the end of the main dam. One on the left bank was near the end of the main dam and the other was 10 miles to the southeast between the English and the Winnipeg River watersheds.

Fig. 7. Caribou Falls second stage unwatering.

Description of Developments

Hydraulic studies indicated 1036 as a desirable normal headwater level at the Whitedog Falls plant. This allowed for 1 ft. of loss in the river channel back to Minaki after channel improvements were made at the head of the Whitedog Falls gorge to reduce the gradient loss through this constriction. The mean low tailwater was set at 982, with channel improvements required at Boundary Falls to achieve this. This elevation will vary with flow conditions. The hydraulic studies showed that high water during flood flow above Minaki would not be higher than in the state of nature. The structures were designed on this basis, with the powerhouse and the headworks located in the river channel near the left or southwest bank and with the erection bay on the shore side, as this was the direction from which the road would reach the plant. The gravity type bulkhead wall extends from the headworks to the 1041 rock contour on the left bank. On the right of the powerhouse is a short bulkhead section with a storage well for service gates. Beyond this is a sluiceway section with nine sluiceways and a log chute headblock. A further section of bulkhead wall ends in a wing wall and short core wall for connection with the earth fill dam which extends to the right bank.

All concrete sections of the dam and headworks were designed to elevation 1041 to allow 5 ft. of freeboard above the regulated high water level. The earth section was designed with a top elevation of 1044, providing 8 ft. of freeboard. It was known that the construction of Caribou Falls would begin in the near future and the access road to this site would have to cross the Winnipeg River. Therefore, the deck of the dam and headworks at Whitedog were designed with sufficient width for use as a single lane roadway.

All concrete sections of the dam and headworks were designed for the following load conditions:

1. Horizontal pressure on the upstream face due to water in the forebay at elevation 1036;

2. Horizontal pressure due to ice assumed to be 10,000 lb. per lin. ft. on concrete and 5,000 lb. per lin. ft. on steel gates, applied at elevation 1035;

3. Uplift on the base of the dam over two-thirds of the area assumed to be full head at the upstream face and decreasing uniformly to zero or to tailrace pressure, if any, at the toe;

4. The unit weight of concrete was taken at 145 lb. per cu. ft.

The controlling requirements for the top width of the bulkhead section was its future use as a roadway and the top width was made 16 ft. The bulkhead section was laid out to be poured in sections 30 ft. long. The highest pour was about 30 ft. Drains were provided near the upstream face at rock level and at horizontal and vertical construction joints, with plastic waterstops across the construction joints upstream from the drains.

The sluiceway section comprises 9 sluices controlled by steel gates. The clear opening of each sluice is 18 ft. in width and the sill is 25 ft. below regulated water level. The total discharge capacity of the sluices is approximately 74,000 cu. ft. per second. This was based on the present capacity of 50,000 cu. ft. per sec. at the control works at Kenora plus possible additions. Two of the sluice gates are screw operated from an overhead bridge. These two gates have a discharge capacity approximately equal to the plant flow and they can be remote controlled either from the powerhouse or from the Kenora control room. The remaining seven gates are operated by the headworks travelling gantry crane. Five of the crane-operated gates are designed for dogging in the fully open position. The remaining two gates located adjacent to the screw-operated gates are designed to be dogged at 6 ft. open and 12 ft. open, in addition to the fully open position. As there is no log driving on this reach of the river at the present, a log chute headblock only was installed and the opening was closed by a removable concrete slab.

Fig. 8. Whitedog Falls powerhouse construction.

The headworks forms part of the dam and is in line with it. The concrete setting and headworks for each unit was designed as a separate structure. An expansion joint extends from forebay to tailrace between each unit and between the units and the bulkhead walls. No reinforcing or ties were allowed to cross these joints. There are three openings in the headworks for each unit. Each opening is 15 ft. wide and is provided with racks and a headgate. Between the racks and the headgate there is a check for service gates. Each of the nine headgates has individual hoists. The lip of the intake at the upstream face is at elevation 1024 and the sill is at 984. This gives a suburgence of 12 ft. and a velocity considering the gross area at the racks of 2.9 ft. per sec. at rated load. The water passage continues at 15 ft. wide past the headgate. The headgate sill is at 977 and the lintel of the opening is at 1001, the velocity at this point under rated load being 4.8 ft. per sec.

Drains and plastic waterstops were required at all construction joints in the headworks, subject to water pressure. The headworks is connected to the powerhouse by a short transition section and is dependent upon the powerhouse to meet the stability requirements previously noted.

The design requirements for Caribou Falls Generating Station were the same as those at Whitedog Falls except that the head was 58 ft. rather than 50 ft. and the deck of the dam and headworks were not designed for use as a road. The area at the racks is the same and the velocity of the water is 3.47 ft. per sec. The headgate opening is 27 ft. high and the velocity is 5.14 ft. per second at rated load. The layout was very similar and the structures had the same relative location, except that an earth fill dam was required on the left bank at Caribou Falls. No core wall or wing wall was used and the earth fill was allowed to wrap around the end of the bulkhead section.

The draft tubes are of the elbow type and are skewed 3° 46′ 41″ to the left of the upstream and downstream centre line. Each unit has two openings with a 6-ft. wide centre pier.

The exit velocity is about 6.3 ft. per sec. under full load. The bottom of the draft tube is 48 ft. below the centre line of the distributor and it extends 62 ft. downstream from the centre line of the unit. The sill of the draft tube outlet is at elevation 939.0 and the lintel is at 957.0 on the centre line. The face of the lintel above the opening was marked on the drawings to be poured to exact dimensions so that the tailrace service gates could be sealed against this surface. Sufficient gates were provided to close all draft tubes from sill to lintel. The gates were to be placed before the tailrace was flooded and sealed at the lintel in the dry. This allowed the tailrace to be flooded before the units were complete. When it is necessary to unwater a draft tube for maintenance there are sufficient gates to close one unit from sill to above high tailwater level, and it will not be necessary to make a seal at the lintel although this has been done on occasion. The draft tube liner and throat ring are 17 ft. in diameter and extend about 10 ft. below the lower ring.

The concrete scroll case has a maximum internal diameter of 55 ft. and the units are spaced at 65-ft. centres. There is no lower stay ring on the turbine and the lower ends of the stay vanes rest on steel pads set in concrete. The scroll case floor was poured in three sections, two flat sections covering the full area, the cone around the unit being the third section. Cutouts were left for the embedded parts and these were grouted in later. The walls and roof were poured separately, the roof originally being designed to be poured in seven sections, but this was later changed to a single pour. All construction joints in the scroll case subject to water pressure were provided with drains and plastic waterstops.

The generators are umbrella type and the generator pedestals rest on the scroll case roof. Walls extending upward from the pedestal to the operating floor enclose the generator area. The only part of the generator above the operating floor level is the exciter and the permanent magnet generator for the governor.

The powerhouse superstructure is a rigid frame steel building, about 58 ft. wide and 260 ft. long including the erection bay. The building is covered with aluminum siding. The transformers are located on the downstream side of the powerhouse on the tailrace deck at operating floor level. Each transformer is surrounded on three sides with concrete flash walls, the upstream

Fig. 9. Whitedog Falls generating station.

wall forming part of the powerhouse wall and acting as a stiffener in the longitudinal direction. A lower steel frame structure to the right of the transformers and attached to the main building houses the metalclad switch gear.

The area between the generator room and the headworks opposite the erection bay and No. 1 unit contains the control room, meter room and temporary living quarters for operating and maintenance personnel. A penthouse on the roof of this area contains ventilation and air-conditioning equipment for the rooms below.

Electrical Equipment

Umbrella-type machines were purchased for both but the design of the supporting brackets was different, as was the location of the cooling coils, which results in different generator pedestals. This is the major difference between the substructures of the two powerhouses. The Whitedog generators are each rated at 24,000 kva., 13.8 kv., 3 phase, 60 cycle, 105.9 r.p.m., 90% power factor. The Caribou Falls generators are each rated at 28,500 kva., 13.8 kv., 3 phase, 60 cycle, 112.5 r.p.m., 90% power factor. Class B insulation was used by both manufacturers and the generators were designed to deliver their rated output without the temperature exceeding 60°C above ambient. The units are capable of operating at an overload of 15% in excess of their rated load without the temperature exceeding 80°C above the ambient. The ambient was assumed to be 40°C. The generators are cooled by a closed air system with air to water heat exchangers. Provision is made to bleed off ventilating air for powerhouse heating. The dampers for controlling the powerhouse heating air close automatically if the carbon dioxide fire protection system on the units is tripped. At Whitedog the generator air system is separated from the turbine pit by a steel plate membrane between the bracket openings. At Caribou Falls the generator pit is open to the turbine area. Each machine is provided with three current transformers on the neutral end of each phase located in the air housing. A primary balanced type current transformer for split phase protection is provided on the line side of each phase. Automatic high speed continuously acting voltage regulators of the static type are provided at each plant with motor-operated voltage adjusting rheostats.

The low voltage switching located on the downstream side of each powerhouse contains three breakers for the generator circuits and two for station service rated at 14.4 kv., 1,500 amperes, 1,000,000 kva. The circuit breakers are metal-enclosed air blast type. At Caribou Falls provision is made to add a breaker for the future supply of local power.

The step-up transformer banks at both stations consist of three single-phase oil-immersed forced air cooled transformers. The transformers at Whitedog Falls are rated at 25,000 kva., 13.5-138 kv. At Caribou Falls the rating is 27,500 kva., 13.5-138 kv. A spare transformer is provided at each station. The high voltage side of each bank is wye connected and the low voltage side is delta connected. Two station service transformers rated at 1,200 kva. are provided at each station. The high-voltage switching for both stations is located at Whitedog Falls. At Caribou Falls provision is made for transformers for future power requirements in the area. These transformers will be located outside the east wall of the powerhouse at the toe of the dam. The generators and switching can be operated from the control room in each station or from a central control room in the Kenora Transformer Station. The sluice gates are operated from the deck of the dam or Kenora Transformer Station. The headgates may be lowered by remote control but must be raised from the headworks hoist house. Contacts are provided so that full remote control of the headgates may be installed in the future if it is required.

Supervisory control equipment, operating via a power line carrier link, is utilized for remote operation of the plants. At present 41 operations at Whitedog Falls Generating Station and 25 operations at Caribou Falls Generating Station can be controlled from Kenora Switching Station. Supervision of equipment at the controlled stations is maintained by light indication on each control feature and approximately 90 alarm indications at each plant. Generator watts and vars are telemetered continuously, while 24 quantities are telemetered on an "as called for" basis.

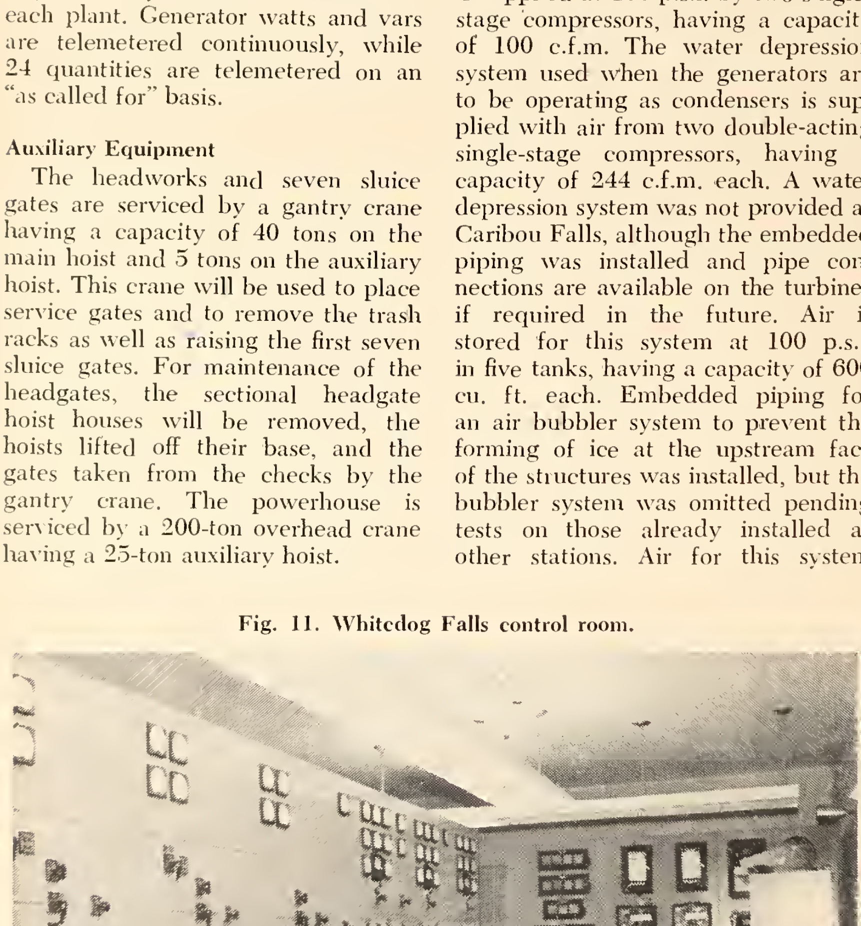
Auxiliary Equipment

The headworks and seven sluice gates are serviced by a gantry crane having a capacity of 40 tons on the main hoist and 5 tons on the auxiliary hoist. This crane will be used to place service gates and to remove the trash racks as well as raising the first seven sluice gates. For maintenance of the headgates, the sectional headgate hoist houses will be removed, the hoists lifted off their base, and the gates taken from the checks by the gantry crane. The powerhouse is serviced by a 200-ton overhead crane having a 25-ton auxiliary hoist.

The generators are protected by both water rings and a carbon dioxide fire protection system. Carbon dioxide fire protection is used for the oil filter room as well as the generators. The system is operated in the generators by thermocouples and by split phase relays. In the oil filter room temperature rate-of-rise devices are used to actuate the system. Water for fire protection is supplied by an electrically driven fire pump with a gasoline-driven pump as a back-up. Fire stands are provided through the powerhouse and the main transformers and station service transformers are protected by automatic deluge systems controlled by temperature rate-of-rise devices.

The governor air supply is from two double-stage air compressors, having a capacity of 38 c.f.m., delivered at 325 p.s.i. The station service air is supplied at 100 p.s.i. by two single-stage compressors, having a capacity of 100 c.f.m. The water depression system used when the generators are to be operating as condensers is supplied with air from two double-acting single-stage compressors, having a capacity of 244 c.f.m. each. A water depression system was not provided at Caribou Falls, although the embedded piping was installed and pipe connections are available on the turbines if required in the future. Air is stored for this system at 100 p.s.i. in five tanks, having a capacity of 600 cu. ft. each. Embedded piping for an air bubbler system to prevent the forming of ice at the upstream face of the structures was installed, but the bubbler system was omitted pending tests on those already installed at other stations. Air for this system would be drawn from the station service air supply.

Fig. 11. Whitedog Falls control room.



For unwatering the draft tubes, one deep well pump of 5,000 gal. per min. capacity under 85-ft. head was supplied. Leakage to the sump from the drainage system of the powerhouse is taken care of by two 500-gal. deep well pumps.

The tailrace deck is serviced by a 25-ton gantry crane for placing and removing tailrace gates. Operating on the same rails is a motor-operated transformer transfer truck, having rails on its deck to receive the wheels of the transformers as they are moved from the pockets. The transfer truck then moves the transformers to rails leading to the erection bay. The transfer truck is motorized for movement along the rails and to operate a hauling winch of the 9,000-lb. capacity to move the transformers out of their pockets.

Unwatering for Construction

The Winnipeg River at the Whitedog site had two channels, but the north channel was small compared to the south or main channel and the invert was high. Therefore, while the north channel took an increased share of the flow during construction, it was necessary to provide a by-pass for the water in the main channel where the powerhouse and dam were to be erected. A by-pass channel was cut in the rock on the north bank of this channel and four sluices with piers and floors were constructed before the rock plug at this upstream end was breached. The piers had checks for closure gates and were spaced so that the service gates for the permanent sluices could be used to make the final closure. When this structure was complete, the timber crib cofferdam around the powerhouse area was tied into the end pier. The diversion sluice piers were continued up to deck elevation of the dam. After the final closure, rollways were poured between these piers and they became part of the permanent sluiceway section. The four diversion sluices could discharge 4,000 c.f.s. each at elevation 1011.0. A deep section in the river bed downstream from the powerhouse provided a good tailrace channel but required a cofferdam of 60 ft. maximum height.

The English River at the Caribou site had a rather wide, flat bed, with rock forming the right bank. The unwatering scheme adopted was to push the river towards the right bank with the first stage cofferdam. The cofferdam enclosed the powerhouse area and the area for six closure sluices

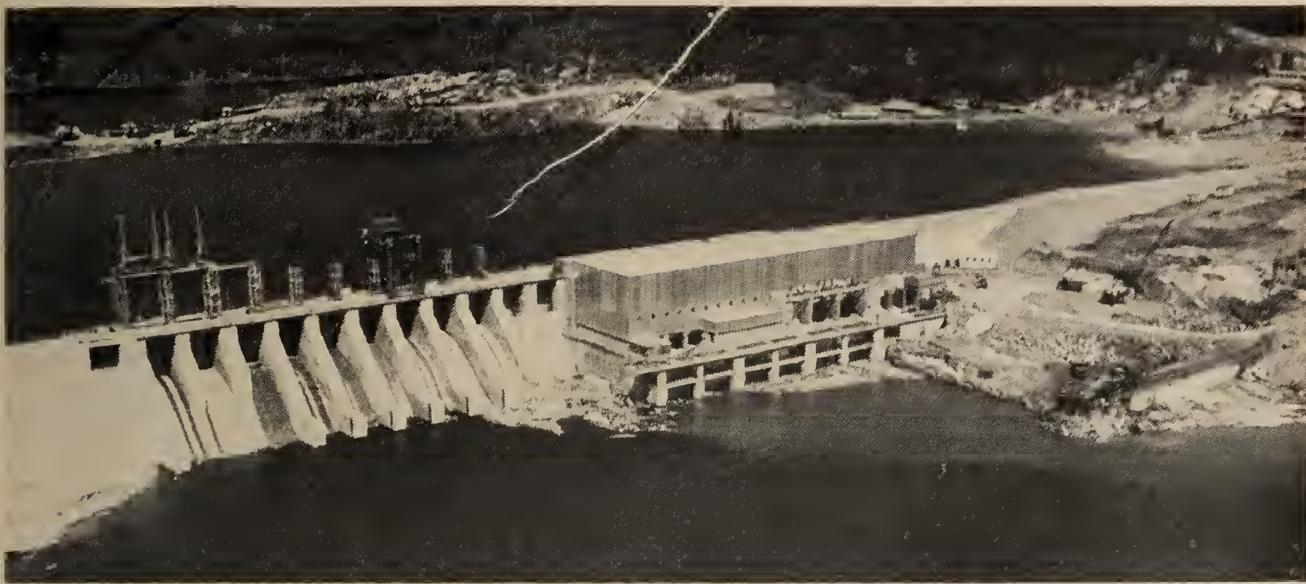


Fig. 10. Caribou Falls generating station.

similar to the four at Whitedog Falls. The cofferdam was arranged so that the powerhouse area would remain dry when the flow was through the diversion sluices and the area for the remaining sluices and the right bulkhead wall was unwatered by the second stage cofferdam. The discharge capacity at headwater elevation 1010 was 30,000 c.f.s. for stage one and 40,000 c.f.s. for stage two. Provision was made for extending the stage one cofferdam to elevation 1012.5 so that 40,000 c.f.s. could be discharged during this stage. The maximum height of the cofferdam was approximately 32 ft. This was on the upstream side.

Construction

Approval for construction of Whitedog Falls was received in August 1955. By early September, the road as located from aerial photographs was being traced on the ground and contract slashers were clearing the right-of-way. A base camp and siding was located at Pistol Lake on the Canadian National Railway 2.5 miles west of Minaki and connected to Minaki by a single lane road. Construction of the two-lane access road was pushed from a base camp and from two intermediate camps that could be supplied by water transport from Pistol Lake. Some supplies were moved in to the power site by barge, a start on the permanent camp was made, and footings were prepared for a Bailey bridge across the Winnipeg River upstream from the powerhouse dam to give access for the construction of the diversion channel.

Autumn rains followed by early freeze-up and heavy snow delayed progress on the road, and it was found necessary to push through a pilot road to bring in material for camp construction. The pilot road could not carry heavy equipment for bridging but early in January 1956 a cofferdam crew was established on the west side of the Winnipeg River in a rehabilitated survey camp, and supplied by barges as the swift water remained open all winter.

Throughout the winter, work continued on the road and heavy equipment was moved to the site over the unfinished road while it was frozen. The construction of the cofferdam continued using B.C. fir and local timber, and by March the Bailey bridge across the river was complete, so that rock from a quarry area on the left bank could be supplied to the cofferdams. By the end of March, drilling and excavation of the diversion channel was under way. Spring break-up caused considerable damage to the road and loads had to be reduced or carried during the night when the ground was frozen. In May a portable aggregate plant was at the site and screening and crushing of aggregates commenced; aggregate was stockpiled over 6-ft. diameter corrugated iron culverts, which were used for reclaiming tunnels. The natural gravel contained insufficient large sizes, and rock from the approach road excavation was crushed in a jaw crusher to make up the deficiency of coarse aggregate. A total of about 87,000 cu. yd. of material was stockpiled near the mixing site. An automatic mixing and batching plant was erected together with the conveyor belts to deliver the aggregate from the stockpiles to the storage bins. Bulk cement was received by rail at Pistol Lake and hauled by truck to a silo at the mixer. Concrete from the mixing plant was hauled to the power site by truck and placed in the forms direct, where possible. For inaccessible forms, concrete was pumped or carried by conveyor belts. Elephant trunks were used for distribution in the forms.

By the end of July 1956, the south bulkhead section had been poured, the diversion channel excavated, and the control piers in the channel poured. The upstream diversion plug was blown in August and by September 1st the water was flowing in the bypass. Due to the rock configuration at the bottom of the stream and to the depth of the river, completion of the main cofferdam and unwatering of the powerhouse site was slow. High flows in the river made the placement of toe fill difficult, and faults in the rock under the upstream cofferdam required grouting. By the time the cofferdam was made tight the water inside the enclosure had frozen, and it had to be removed as excavation rather than by pumps. Thus it was late 1956 before rock excavation could begin in the powerhouse area.

During the summer the work had continued on the bulkhead section and the camp had been completed to house about 800 men. Most of the buildings were prefabricated steel of various types and brands. The camp contained cafeteria, recreation hall and bowling alley, storage buildings, post office, grocery store, and houses for senior personnel. Junior personnel were housed in trailers. Married workmen were rented material to build their own houses according to plans provided. Serviced lots were provided on a rental basis for the houses and for those who wished to bring trailers. All buildings were serviced with electric power, sewage and water. Commission buildings and houses were supplied with heat from oil burning boilers, each boiler serving two or more buildings, depending on the size of the building and the heating unit.

Pouring of the bulkhead walls and sluiceway section continued during the fall and winter of 1956 and 1957. The first concrete in the base of the powerhouse for No. 2 draft tube was placed in March 1957. Bailey bridges were constructed across the powerhouse area and over the headworks area for the supply of materials and concrete. Intermediate footings for the powerhouse bridge were moved back and forth as the different pours were made, to avoid embedment of the footings of the permanent structure. This bridge in the powerhouse area was used to place the embedded parts for the turbines and was left in place until the main powerhouse crane was in service in September 1957.

During June and early July of 1957 the watershed of the Lake of the Woods received exceptionally heavy rainfall, and as the lake was nearly full from spring run-off it was necessary to discharge about 35,000 c.f.s. at Kenora. Considerable concern was felt for the cofferdams and the upstream cofferdam was raised. The flood was passed without serious damage, although several rather serious leaks developed.

Work progressed on a double shift basis throughout the summer and fall of 1957 in order to make up for the time lost in road building and unwatering. To further this end, consideration was given to pouring the scroll case roofs in one pour instead of in seven as is normal practice for units of this large size. Due to the density of the reinforcing and its complex pattern, considerable time would have been required to form the bulkheads for the sections and there would be a waiting period between pours in order to obtain the results desired from the multi-pour method. It was decided to pour No. 1 roof in one pour as an experiment, subject to the following conditions: Fly ash was to be used in the concrete to reduce the heat of the hydration and the shrinkage and to extend the initial set period; no cold joints were allowed and the differential pressure on the embedded parts of the turbine was limited to not more than that caused by 8 in. of fresh concrete; since the mixing plant contained only one two-yard mixer it was required that either an additional mixer be added or that the Caribou Falls plant be used as a standby, with the ready-mix trucks available to haul the concrete 17 miles to Whitedog. This procedure proved successful with only minor cracking of the concrete, and the method was adopted for the scroll case roof throughout the job. The area of the scroll case roof was approximately 65 ft. by 60 ft. with a 20-ft. diameter opening in the centre for the turbine pit. A total of about 875 cu. yd. of concrete was required for each roof.

By the time the weather became cold in the fall of 1957, the erection bay and No. 1 unit area were advanced far enough to be covered by a permanent superstructure, and the powerhouse crane was erected in this area. It was necessary to protect local areas of units 2 and 3 by tarpaulin covers and heat them with steam as the pours were made. Moving parts of the turbine and all generator parts were placed, using the powerhouse crane. Generator erection commenced in November 1957.

The final clean-up of the flooded area continued throughout the fall of 1957 when weather conditions permitted burning of brush. Work on the upstream channel improvements that had been interrupted by the high flows during the summer was completed shortly after Christmas. Fast water and cold weather combined to make this operation very difficult in winter time.

In October 1957 the river flow was about 13,000 c.f.s. and as the upstream cofferdam had been constructed to a height which would pass 35,000 c.f.s. through the four diversion sluices, the gates in one diversion sluice were placed and the rollway was poured for the permanent sluice. The volume required to fill the headpond was only about 13,000 acre-ft., but this had to be accumulated gradually so as not to withhold water from downstream plants. After the cofferdams were removed in late November, the Lake of the Woods Control Board were requested to slightly increase the discharge from the Lake of the Woods above that required by the Manitoba Plants. The remaining three diversion sluices were then closed one at a time, the gates being placed in each sluice as the water rose, so as to maintain a constant flow. As each sluice was closed, the permanent rollway was poured and the sills and gates installed. After the headpond level was above elevation 1011 (the sill elevation of the sluices) the discharge was controlled by the completed sluices. By February 11, 1958, the headpond was within operating range and No. 1 unit was ready for service. No. 2 unit was placed in service on March 25th and No. 3 on June 6th. Work on the finish floor, clean-up and painting continued during the summer of 1958.

Construction of Caribou Falls was approved in June 1956. Power requirements and river flows combined to force a very tight schedule. An immediate start was made on an access road that was an extension of the Whitedog access road. The extension commenced at the Bailey bridge crossing the Winnipeg River just above the Whitedog Falls. The road specifications were changed in order to speed up the work. Instead of grubbing and removing forest litter, the trees were close cut and excavation from the ditches was placed on the surface to form the sub-base. This was supplemented where necessary by fill from local borrow pits along the road without respect to type of material. The finished sub-grade was to be topped with 18 in. of granular material. Work on the road was carried on from the Whitedog Falls camp and from the Caribou end of the road, with an intermediate camp that could be supplied by barge. Tetu Lake, being the tailwater of both plants, provided an excellent water route from Whitedog Falls to Caribou Falls, and full use of this was made in the transportation of equipment and supplies until the road was passable. A temporary camp that had been in use for preliminary investigation was extended for use by road-building, cofferdam and camp-building crews. By New Year 1957, the permanent camp at Caribou was ready for occupancy, and the sub-grade of the road was complete with sections where the granular surfacing material had been placed. The clay sub-grade of the road had frozen hard and this was covered by a thin layer of granular material on the uncompleted sections. In this condition the road was used throughout the winter, and sufficient heavy equipment and supplies were brought in to cover the period in the spring when it was known the road would break up. During and after break-up, additional granular material was added where required and the road compacted. As the road proved serviceable in this condition the full 18 in. of granular material was not placed.

A mixing and batching plant containing two 2-yd. mixers was erected during the winter and sufficient coarse aggregate hauled from Whitedog Falls to supply the plant until aggregate crushed from the powerhouse excavation would be available. A large pit containing fine aggregate was located near the site. One section of this pit contained 20,000 yd. that would meet the concrete specifications for fine aggregate without screening. This material was placed in stockpiles for reclaiming, similar to that at Whitedog. The mixing plant was located so that concrete could be supplied direct to the forms by pumping or by truck. The sand was found to contain a natural air entraining agent which, combined with the additive used, entrained so much air that the pump would not work and had to be abandoned.

Cofferdamming progressed well during the winter in spite of extremely cold weather. The first-stage cofferdam consisted of a square enclosing the powerhouse area and an adjoining rectangle extending into the river with the upstream edge of the two in line. Construction of the upstream and downstream cofferdams was carried on simultaneously. As the upstream cofferdam was extended it was followed downstream by a causeway to the junction of the side of the square and the downstream side of the rectangle. When this point was reached, a corner crib was placed and two more working faces were available. It soon became evident that the rectangular section was crossed in an upstream and downstream direction by a ridge of rock which almost separated it from the powerhouse area. A temporary earth dyke was built on this ridge, allowing the powerhouse area to be pumped out and excavation to start well ahead of the completion of the first-stage cofferdam.

During the early spring of 1957, concrete was poured in the east bulkhead section and a Bailey bridge from the outstream end of the cofferdam to the west shore of the river permitted pouring to begin on the west bulkhead by the end of May. The first base slabs for the draft tubes were poured in August. By September the diversion sluices were ready for use and it was certain that final closure would be made during the spring of 1958 to catch the freshet. As water levels were low on the watershed and no fall freshet was expected to occur, the permanent rollways were poured in two of the six diversion sluices before flooding the diversion area. The four diversion sluices left open were in use by the end of September. Construction procedures were similar to those at Whitedog, except that a Bailey bridge was used in the powerhouse area only and none at the headworks. Steel columns were used as intermediate supports and these were imbedded in the final structure. The headworks were poured from the deck of the bulkhead section and from the deck of the adjoining headworks structure.

One of the major items in the construction of Caribou was the clearing of 18,800 acres of land to be flooded in the headpond, and the salvaging of approximately 27,000 cords of pulpwood from this clearing. The headpond extended some 30 miles along the river and intervening lakes, and had a shoreline of about 500 miles. Mosaics of the flooded area were made from aerial photographs and the flooded contour of 1044 was marked on these by photogrammetric means. The area to be flooded was divided on the mosaic into approximately 30-acre blocks. The clearing of each block was contracted to a group of three or four men, at a price per acre with an extra allowance per cord of pulpwood piled, when indicated. At one time nearly 400 men were under contract on this work. Areas cleared were measured for progress payments and final payment from aerial photographs taken at two-week intervals. The contractors were instructed to leave a few trees standing on the edge of their blocks to indicate the boundaries. These trees were easily identified on the aerial photographs and the areas for payment were measured by planimeter.

Water level gauges were set on different reachs of the stream by engineer's level and water transfer. Bench marks set on the flooded contour at convenient intervals by running level lines from the water's edge to the contour by engineer's level. The contour between bench marks was then run by hand level and marked by blazing the trees.

An operation extending over such a wide area presented a difficult problem in supply and supervision. During the open season supervisors used boats to visit the contractors and carried provisions ordered previously. When the river and lakes were frozen, light tractors and snowmobiles were used. Depots were established at conveniently located points around the headpond and stocked with the supplies for use during the break-up and freeze-up. Since nearly all the contractors used power saws, large stocks of gasoline and spare parts of the various makes of saws were necessary. For travelling during break-up a light punt driven by an airplane motor and propeller was found convenient. This machine could travel on either ice or water. The continuous engine maintenance required made these vehicles unreliable. During the break-up of 1957 a helicopter was retained for emergency use, and during times of high fire hazard daily airplane patrol was maintained.

By the autumn of 1957 cutting was complete, but the salvage of pulpwood presented a difficult problem. The areas where pulpwood was to be salvaged were small and were scattered over the whole flooded area, some very remote from the then existing river system. Some wood was removed by truck over the ice early in 1957 and some easily accessible wood was skidded to the water during the summer and towed to Caribou Falls, where it was trucked to rail at Pistol Lake. During the winter of 1957 and 1958 large amounts of pulpwood were hauled by truck to the lakes and placed in booms on the ice. In some inaccessible areas the 2-cord piles of pulpwood were banded with high-strength steel wire and allowed to float up when the water was raised. This procedure was only partially successful as the bundles had to be separated from other floating trash and collected into booms. In one area, which formed a nearly closed bay when the water rose, the muskeg at the mouth of the bay, complete with stumps, floated up and blocked the entrance to the bay.

Earth Fill Dams

The overall construction schedule required that all the earth fill dams be complete by the spring of 1958. This meant that the dams would all have to be constructed during the summer of 1957. The season during which earth fill dams may be constructed in this area is short, as the ground remains wet until late in the spring and heavy rains and frost may be expected in September. As some of the block dam sites had perched water tables, ditches were cut to drain two of these in the fall of 1956. Due to the topography and vegetable matter in the top soil, the drainage even with the ditches was very poor.

Sufficient earth-moving equipment to work at two sites at once was supplied well in advance, so that work could commence as soon as the sites were workable. Tests run on samples of the clay showed that while it would make good core material, it was subject to expansion on wetting, and heavy rock cover would be necessary to overcome the expansive effect. Rock was available at all sites and sufficient rock for loading and for riprap was drilled and blasted early in the season before it was possible to work on the clay sections.

Completion of the earth wing dam on the right bank at Whitedog Falls would facilitate delivery of material to the dam and powerhouse, as when it was complete, trucks could make a circuit over the dam without having to back off. The site was stripped to bedrock in early June and a bad fissure was found in the rock. The fissure was excavated down to sound rock and backfilled with concrete. The clay borrow pit was in a well drained position, but it was nearly the end of June before the water content was low enough to meet the specifications for good compaction. The clay core around the end of the concrete bulkhead and wing wall was compacted by hand rammers and the main section by smooth rollers and tractors. After the clay core was complete, the granular material and riprap were placed as convenient.

In July the sites of the west block dams and Goshawk dam for Caribou were stripped of vegetable matter and drained. These sites were allowed to dry, and work proceeded on the east block dam at Caribou and the west block dam at Whitedog. The Goshawk lake dam and No. 2 west block dam for Caribou Falls were the largest earth structures and required careful work. A soils testing laboratory had been set up in the field to control the borrow material and to check on the compaction of the material in place, as continued testing was necessary. Difficulty was encountered in draining the foundation and in maintaining proper moisture content of the fill. The natural water content of the material in the borrow pits was from 25 to 30%, varying with depth. The plastic limit was about 32% and the plasticity index about 47. Rains during the night would prevent work from commencing until late in the morning and during the day drying winds would make the addition of water necessary by 2:00 p.m., even though the material had been too wet in the morning. Although the clay beds were extensive, being part of the bed of prehistoric Lake Agassiz, the characteristics of the material varied greatly with depth and in different sections of the borrow pits. By September 6th, the clay cores of five dams were complete and the east wing wall at Caribou with its adjacent clay blanket was well under way. This blanket was necessary to seal the dam to the rock along the original river bank, where sand was exposed between the rock and the natural clay. This blanket also covered any punctures in the clay blanket made by construction activities. The placement of granular material continued throughout the fall and was complete in late November. Despite the fact that the dams had been designed to use local material, large enough deposits having proper grading in the natural state for filter material could not be located and it was necessary to crush and screen blending gravel for the filters and topping.

The block dam in the north channel of the Winnipeg River was left as long as possible to reduce the flow past the Whitedog powerhouse site. This structure was founded on exposed bedrock in the north channel of the river and was designed for winter construction without unwatering the site. Rock from a bluff on the bank was blasted into the stream and bulldozed to form a barrier of proper dimensions across the channel. Graded materials were then dumped on the upstream side to form a filter and an impervious blanket. Silty gravel and sand were used instead of clay, as these handled better in the cold weather. The impervious layer was then covered with riprap. The operation was successfully completed and there is very little leakage from this structure. It is believed that this small amount of leakage comes through fissures in the adjacent rock.

By March 1958, the dams and headworks for the Caribou Falls Generating Station were sufficiently complete to allow the headpond to be raised and final closure made. This operation required special study, as approximately 1,500,000 acre-ft. of water were required to fill the headpond.

In the summer of 1957 a canal and control works were constructed to divert water from Lake St. Joseph on the Albany River watershed to Lac Seul. During the winter of 1957 and 1958, as water was withdrawn from Lac Seul for power purposes on the English and Winnipeg rivers, water was diverted from the Albany River and stored in Lac Seul. By March of 1957, when the Caribou headpond was ready for filling, approximately 700,000 acre-ft. of water were available in Lac Seul for the filling operation. About two weeks before the closure commenced at Caribou Falls, the Ear Falls dam was opened to discharge this water at a rate of about 6,000 c.f.s. Two weeks was the time estimated for the water to traverse approximately 125 miles of river from Lac Seul to Caribou Falls. Closure was made in a manner similar to that at Whitedog, the same gates being used and the headpond being raised at such a rate that only water equivalent to that from the diversion was stored. As the spring progressed and the freshet started, close cooperation was maintained with the Manitoba plants downstream, so that any flow in the English River which when combined with that from the Winnipeg River would be in excess of their requirements would be stored in the Caribou headpond. While the spring freshet of 1958 was very low on the English River, a good run-off was received from the Albany River diversion and by July 8, 1958, the headpond at Caribou Falls was raised to operating level.

The downstream cofferdam below the powerhouse had been located by balancing the extra cost and time of building cofferdams against the added cost of excavating rock under water. The final location was such that about 15 ft. of rock under the cofferdam and tapering to nothing downstream had to be excavated. This rock was drilled fanwise from the dry side of the cofferdam and blasted before the cofferdam was breached. A timber barrier was placed near the cofferdam to prevent damage to the downstream side of the powerhouse and the transformers located some 150 ft. away. The blast was successful in breaking the rock and leaving the cofferdam sufficiently intact so that a dragline and trucks could work over the top of it for removal of the cofferdam and broken rock. The area within the cofferdam gradually filled with water and no material was washed towards the powerhouse. The No. 1 unit was placed in service on July 27, 1958, No. 2 on September 11th, and No. 3 on October 11th. Thus Caribou Falls Generating Station was completed and on the line in slightly over two years, in spite of the fact that it was located far from the sources of supply and 17 miles of access road had to be built to reach the site.

During the summer of 1958 channel improvements at Boundary Falls were carried out. This involved the removal of some 47,000 cu. yd. of

(Continued on page 95)

THE FIRST CYCLONE FIRED BOILERS IN CANADA AND SOME ASPECTS OF THEIR EARLY OPERATION

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THE cyclone fired boilers, which have a combined peak load capacity of 1,000,000 lb. of steam per hour, are known as Units Nos. 6 and 7 in the Water Street plant of Nova Scotia Light and Power Company, Limited, at Halifax, N.S. These boilers are unique in that they are the first of this type to be installed in Canada. In the range of operating pressure and temperature, they rank with the largest at present operating in this country, and in fact are the largest boilers in operation in the Maritimes.

No. 6 boiler, the first cyclone fired unit to be commissioned, went into commercial operation in October, 1957. Although this boiler did not run continuously during its early stages of operation, it did prove invaluable in bolstering system output and taking care of system peak conditions, particularly as water storages for the system's hydro plants were in short supply because of a prolonged spell of dry weather.

No. 7 boiler was put into operation in September, 1958, and since the steam mains for these two boilers are cross connected, it has been available as a 100% standby for No. 6 boiler.

The addition of these two cyclone fired boilers together with two turbo-alternator sets increases the plant capability by 100 mw. and represents the last phase of construction at the Water Street site. With the commissioning of No. 7 turbo-alternator, now scheduled for July or August of this year, the total plant capability will be 180 mw. This is supplemented by approximately 41 mw. of hydro capacity to make a total for the system of 221 mw.

Fig. 1. Exterior View of Plant overlooking Halifax Harbour.

Further expansion of the steam generating facilities of the Company will necessitate the development of the new Tufts Cove site, which is located on the Dartmouth or eastern side of Halifax Harbour.

History

At this stage it may be in order to review the development and growth of the present Water Street Plant. Fig. 2 shows the general plant arrangement.

Between the years 1944 and 1955, four turbo-alternator sets together with the necessary boiler plant to supply the steam for their operation, were installed at the Water Street site. These units were all designed for steam conditions of 600 p.s.i.g., 815° F. As will be seen from Table I, the last three of these units were installed at two year intervals in order to keep pace with the growing demand for electrical energy.

Table I

Turbo-Alternator	*Capacity K.W.*	*Commissioned*
No. 2	12,500	1944
No. 3	20,000	1951
No. 4	22,000	1953
No. 5	25,000	1955

During this same period approximately 21,000 kw. of hydro capacity was added to the system.

Early in 1954, with the system load growth still increasing at the rate of 10 to 12% per year, it became apparent that additional steam generating plant would have to be installed for operation in the fall of 1957. Having established that this was necessary to take care of the growing system requirements, the next step was to decide on such things as the steam pressure and temperature to be selected, the size of unit or units to be installed, and also the location for this additional plant.

With reference to plant location, studies were carried out in order to determine whether or not the additional capacity should be added to the Water Street Plant or if the new Tufts Cove site should be developed at this stage. The studies indicated many apparent advantages to remaining at the present site, and after due consideration it was decided to follow this course of action.

Over the years one of the principle aims of power utilities has been the production of electrical energy at the lowest possible cost. In this respect we need not look backward many years to note the tremendous strides that have been made in this direction. During the early 1920's, the average thermal plant required approximately 3 lb. of coal to produce 1 kwh. of electricity; by the early 1930's this figure had been halved, or reduced to 1.5 lb. of coal per kwh. Today a considerable number of plants are producing a kwh. for 1 lb. of coal or less and a few of the leading plants on this continent are producing a kwh. for as little as ¾ lb. of coal. It has been through the progressive thinking and foresight of power utility engineers and equipment manufacturers that such impressive savings have been made possible.

Today we are just entering the age of atomic power generation. Relative operating and capital costs of atomic plants as compared with similar costs of conventional plants burning fossil fuels, will to a large extent determine the rate of development and widespread use of this new method of power generation.

In some countries, the scarcity of fossil fuels and their relatively high cost will, of course, accelerate the rate of development of atomic plants.

However, over the next number of years many conventional plants designed to burn fossil fuels will be built and put into operation; and at the same time the better grades of coal required to fuel these plants will become scarcer and more expensive as time goes on. Therefore, larger and larger quantities of the poorer grades of coal will of necessity have to be burned for the generation of power.

The development of the cyclone furnace was, in part, brought about by the need for a furnace capable of burning a wider variety of poorer quality coals while maintaining efficiencies at least as high as other types of conventional coal burning units.

The Company has always been interested in the utilization of Nova Scotia coals and considered cyclone fired units should prove to be well suited for burning this class of fuel. Operating experience to date, although not completely trouble free, has proved that these units are well suited to burn Nova Scotia coals.

In selecting cyclone fired boilers for the final extension to the Water Street Plant, some of the factors influencing the choice, and from which it was hoped to derive some benefits in this particular application, are listed below:

1) The cyclone fired boilers would occupy less space than most other conventional types having the same capacity;

2) With few exceptions, the characteristics of Nova Scotia coals are well suited for cyclone firing;

3) Cyclone ash or slag is easier to handle and more readily disposed of;

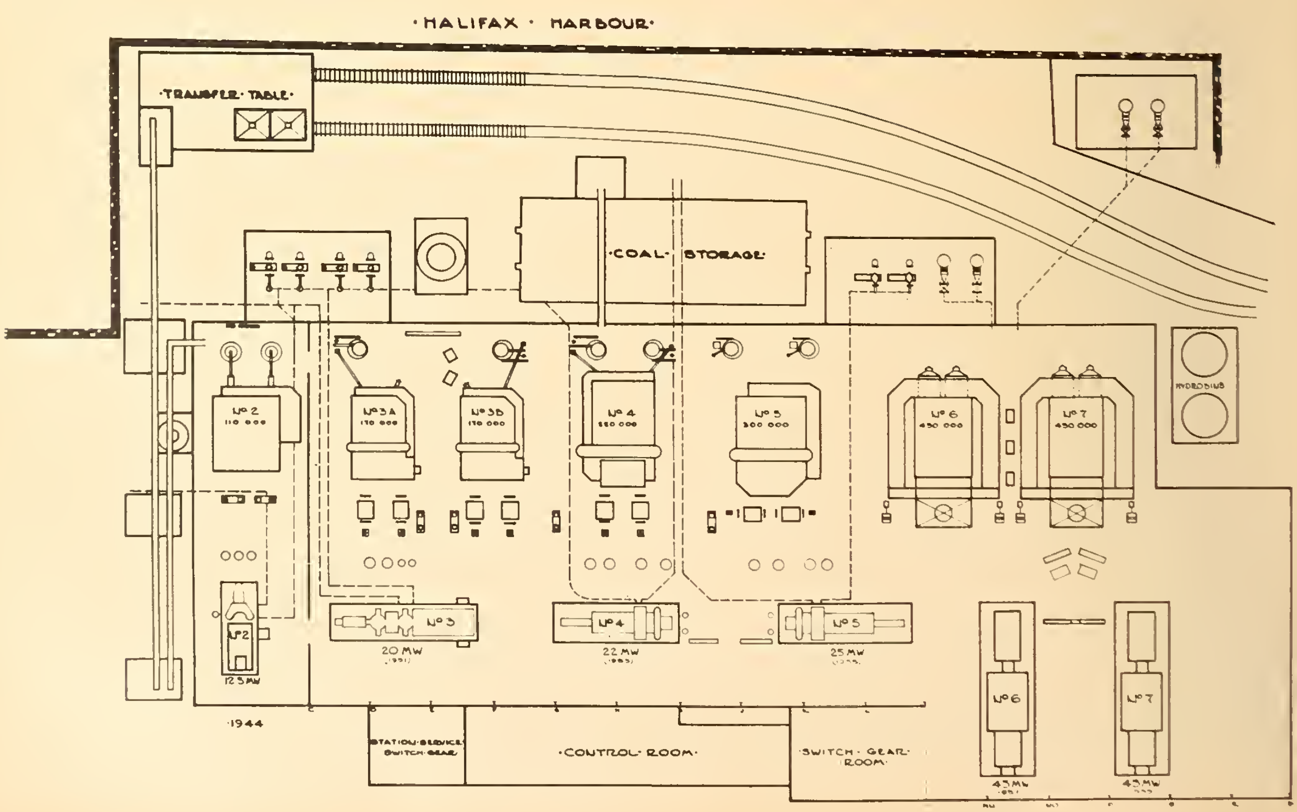
4) Less stack emission and possible elimination of dust collector equipment;

5) Since the coal is crushed and not pulverized, a considerable power saving results from the coarser preparation;

6) Safety of operation since the risk of furnace explosions is largely eliminated when burning coal;

7) Only two cyclone burners would be required as compared to 8 or 9 burners for pulverized fuel firing for

Fig. 2. Plan of Power House Arrangement.



a boiler of the same capacity;

8) Due to the smaller number of burners, cyclone firing is admirably suited to remote automatic control;

9) The heavy foundations required for pulverizers are eliminated as well as the pulverizers themselves, together with their driving motors, blowers and associated switchgear;

10) A considerable reduction in maintenance costs is expected due to a reduction in the number of moving parts and elimination of the pulverizers;

11) Cyclone firing offered possibilities of attaining efficiencies higher than other types of combustion equipment.

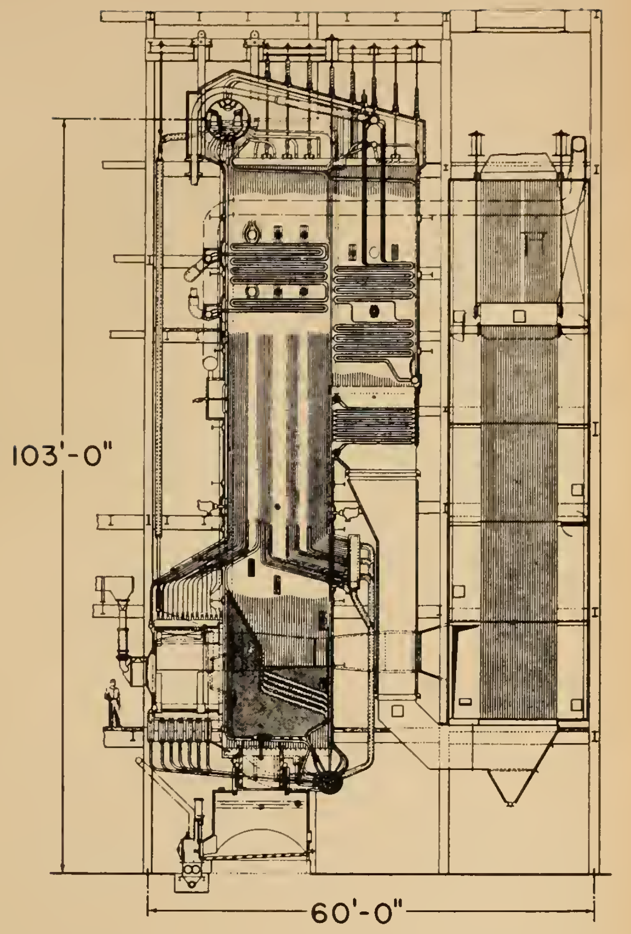


Fig. 3. Sectional Elevation of Boiler.

Boilers

A typical section through the boilers is shown in Fig. 3 from which you will note that the boilers are suspended directly from the building steelwork by a series of drum straps and hanger rods. Suspended in this manner, the units are free to expand radially and downward as the temperature increases. The distance from the centre line of the steam drum to the ground floor level measures 103 ft., and the total downward movement due to expansion between cold and operating temperature is of the order of 3½ in. This movement is taken care of by means of a water seal trough which is located between the neck of the slag tank and the furnace floor.

The steam generators are identical with respect to size and capacity, each having a continuous steaming rate of 450,000 lb. of steam per hour and a two hour peak rating of 500,000 lb. per hour. Specified steam conditions at the superheater outlet are 925 p.s.i.g., and 915°F. plus or minus 10°; this steam temperature being maintained for all loads above the control point of 225,000 lb./hr. In practice, a steam temperature 915°F. is usually maintained for loads down to about 180,000 lb. per hr. For the higher loads above the control point outlet steam temperature is controlled by direct injection of boiler feeder water into a venturi type attemporator. This attemporator is located in a section of 10 in. pipe connecting the primary and secondary superheaters.

Each boiler unit consists essentially of two cyclone furnaces, primary and secondary furnace, primary and secondary superheater with an inter-stage attemporator, economizer, air heater and chimney. The auxiliary equipment consists of two forced draft blowers per unit with inlet control dampers and outlet isolating dampers; spark ignited automatic oil lighters for the cyclones, and high level oil lighters and burners for quick starting or for two shifting operation, as well as two drag type coal feeders with variable speed drives for each unit.

In addition to the above equipment, each unit is provided with full capacity secondary air port bunker "C" oil burners and the necessary bunker "C" oil pumping and heating sets.

Since these two boilers have been designed for pressure firing no induced draft fans are required. However, this presents a problem in that all door openings and observation ports required for inspection purposes must be supplied with cooling and sealing air and also with an aspirating air supply. Air lock arrangements have been provided so that before any inspection doors can be opened, the cooling air supply, shut off; and aspirating air turned on to prevent hot gases from rushing out.

The cyclone furnaces (2 per boiler) are located side by side on the lower front wall of the furnace. They are made up from an intricate arrangement of bent tubes and headers and may be described as being fully water cooled, horizontal cylinders, 8 ft. in diameter by about 11 ft. long, into which fuel is fired. Figs. 4 & 5 illustrate the general arrangement of a cyclone furnace. The tube surfaces forming the inside surface of the cyclone are studded and covered with a refractory material as a base for slag adhesion. Crushed coal falls by gravity from the discharge end of the coal feeders and enters the vortex or outer end of the cyclone burner. High temperature primary air, representing approximately 15% of the total air required for combustion, enters the side of the burnerscroll at high velocity and imparts a whirling motion to the particles of coal, carrying them into the larger cylinders of the cyclone furnace. Here the whirling or centrifugal action of the coal air mixture is further increased by the secondary air flow which enters the cyclone tangentially at velocities of some 350 ft. per sec. The centrifugal force tends to throw the fuel particles to the cyclone walls where they are captured in the molten slag layer. The high temperature, high velocity air sweeps past the particles of coal embedded in the molten slag layer inside the cyclone furnace. In this way there is very rapid and intimate mixing of air and

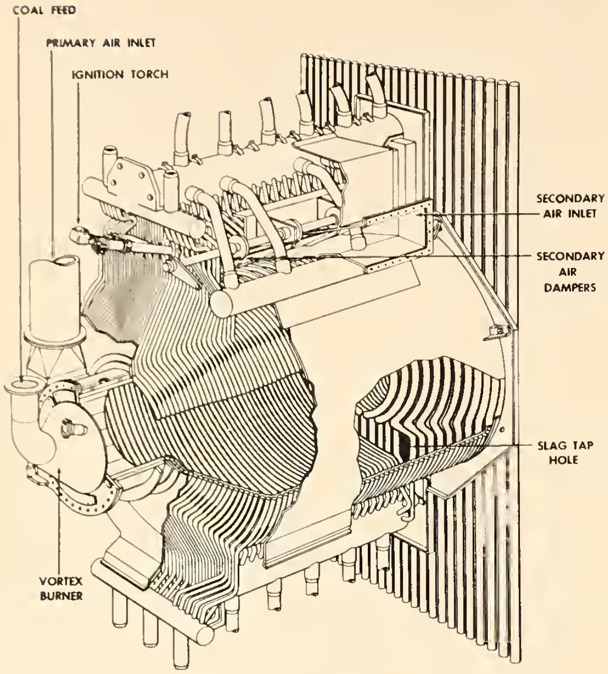


Fig. 4. The Cyclone Furnace.

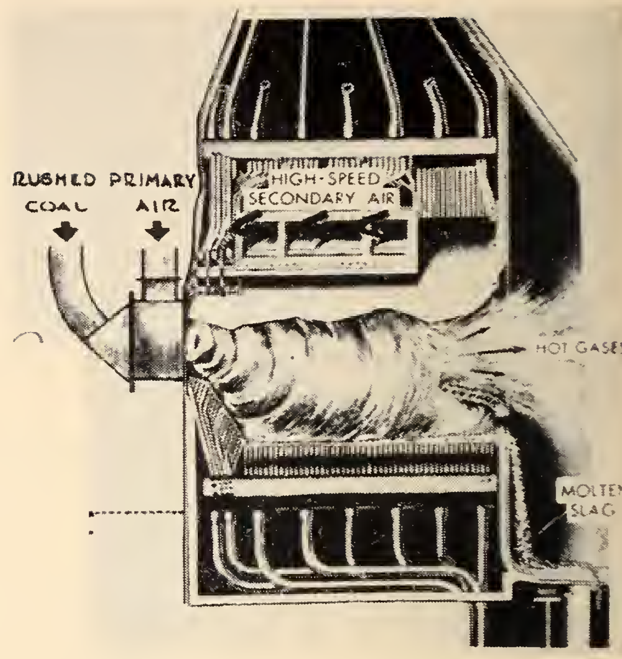


Fig. 5. A Section through the Cyclone Furnace.

the coal gases generated, and sufficient oxygen is very rapidly supplied to promote high speed burning. Heat releases at full load are of the order of 500,000 Btu. per cu. ft. per hr., and gas temperatures 3000°F. or higher.

The film of molten slag, covering the walls of the cyclone furnace, flows gradually toward the rear of the furnace, drains through a tap-hole, and continues downward to the slag pool on the floor of the primary furnace. From this point it passes through a water-cooled slag spout and is discharged to the slag tank filled with water.

During normal operation combustion is substantially complete in the cyclone furnace, the products of combustion pass through the water-cooled re-entrant throats and into the primary furnace. The re-entrant throat sections made up of studded tubes —illustrated in Fig. 6—are shipped to the job as assembled units and form a part of the main circulation of the front wall of the primary furnace. Again the primary furnace and screen tube sections are all constructed of studded tubes and coated with a refractory material. The purpose of this type of refractory covered construction is to present a surface which will maintain a molten slag cover and thus act like fly-paper in capturing and retaining any particles of coal or ash which come in contact with these molten surfaces. The screen tube section which is made up of four layers of staggered tubes on about 14 in. centers is likewise very effective in capturing any fly ash particles, since these studded tubes also present a sticky surface coated with molten slag.

The flow of gases from the cyclones on entering the primary furnace is deflected downward by the close spaced tube arrangement in such a way that the hot gases sweep over the furnace floor and thus keep the surface of the slag accumulated on the floor in a molten state. The gases then flow through the slag screen which separates the primary and secondary furnaces. The remaining ash particles which have escaped from the cyclone furnaces are nearly all trapped in the molten slag layer covering the primary furnace walls and the screen tubes.

After passing through the screen tubes the gases, in addition to being cooled by the close spaced furnace wall tubes, are also further cooled by three division wall platens projecting into the furnace in such a way as to divide the secondary furnace into four chambers. Since these division wall tubes are completely surrounded by hot gases their entire surface is utilized in heat absorption.

The hot gases rising up through the secondary furnace pass, at right angles, over the secondary or outlet superheater tubes. Thence, horizontally across the top of the furnace; then downward through the primary superheater tube bank and the economizer section. Both the primary and secondary superheater tube banks are arranged between headers in such a way as to be completely drainable.

Beyond the economizer, the flow of gases is downward through a section of ductwork to the bottom or inlet end of the air heater. From this point the flow is upward through the vertical tubular air heater which is constructed in two sections. The hot section contains 3381-2 in. tubes 54 ft. long, and the cold or outlet end contains 2949-2 in. tubes, 17 ft. long. The air heater has been divided into two sections to facilitate maintenance of the cold end where corrosion problems are most frequently encountered.

The gases leaving the air heater have been cooled to about 266° for full load rating on the boiler and the incoming air elevated to 560°F.

Table II gives some design data and the expected performance figures for coal firing.

The expected performance figures for coal firing have not as yet been substantiated by actual tests. However, various observations appear to indicate that the efficiency of these units will be close to the predicted values. Present plans are to carry out full scale tests shortly after the commissioning of No. 7 Turbo-alternator which is at present scheduled to go into operation this July.

Special Features

Some of the special features incorporated in the design of these steam generators merit special attention and will be discussed briefly in the following order:

(1) All welded construction;
(2) Pressure casing;
(3) Water Column TV and other water level indications;
(4) High level oil burners;
(5) Full capacity Bunker "C" Oil Burners.

All Welded Construction

Specifications for most large boiler and turbine units being installed today require that they shall be suitable for two shift operation and for quick start-up. Since these last two units represent a large percentage of the total system capacity it was mandatory that they should fall within this class and at the same time be capable of two shift operation without sacrificing anything in the way of reliability or availability.

Past experience has emphasized the fact that repeated cycles of pressure and temperature fluctuations such as encountered with two shift operation are a prime factor in promoting leaks in such items as flanged joints, boiler hand hole gaskets, and at tube expansions.

Table II Design Data

Maximum Continuous Rating Lbs./Hr.	450,000		
Peak Capacity 2 Hour Duration	500,000		
Design Efficiency %	90.06		
Design Pressure psi	1,100		
Operating Pressure (S.H. Outlet) psi	925		
Total Steam Temperature °F	915		
Number of Burners	2		
Diameter of Cyclone	8 ft.		
Coal	Nova Scotia		
Btu/lb. (as fired)	12,500		
Ash Softening Temp. °F	1,900		
Expected Performance			
Steam M Lbs./Hr.	100	225	450
Excess Air %	29	14	12
Coal M Lbs./Hr.	9.1	22.6	42.8
Flue Gas Entering Stack °F	200	229	266
Water Entering Economizer °F	355	355	415
Air Leaving Air Heater °F	400	461	560
Calculated Heat Losses % at M Lbs./Hr.	100	225	450
Dry Gas Loss	2.01	2.55	3.29
All Moisture Sources	4.50	4.57	4.67
Unburned Combustible	0.10	0.10	0.10
Radiation	1.71	0.76	0.38
Unaccounted for	1.50	1.50	1.50
Total Heat Loss	9.82	9.48	9.94
Efficiency	90.18	90.52	90.06
Heating Surfaces			
Boiler and Furnace	35,783 sq. ft.		
Superheater	18,830 sq. ft.		
Air Heater	123,630 sq. ft.		
Economizer	7,280 sq. ft.		

As a preventive step in this direction the boilers were designed for all welded construction in the field, that is to say, the boiler drums and all headers were supplied with stub tubes strength welded in position prior to being stress relieved in the shops. Figs. 7 and 8 show a steam drum and various headers with stub tubes projecting. To erect the units, with this type of construction, it was only necessary to weld the various components together, thus tube expanding was 100% eliminated for the boiler pressure parts. As a further safe-guard from the point of view of reliability all hand hole caps were designed to be seal-welded in place.

As might be expected this feature of all welded construction has been followed throughout for both the main steam and feed water piping systems.

High Level Oil Burners

In addition to being suitable for two shift operation and quick start-up, a further requirement laid down in the specifications was that the boilers were to be capable of delivering steam at or close to full design temperature for hot starting the turbines. On a two shifting schedule where a unit is shut down each night and brought on the line again the following morning the actual steam temperature required initially will depend on the temperature of the turbine at the time of shut down, its rate of cooling during the night and the duration of the shut down. The average cooling rate for the high pressure turbine cylinder is usually about 25° F. per hour. The desired steam temperature for hot start-up is generally specified as not less than the temperature of the turbine casing and preferably up to 150°F. above this temperature.

This requirement has been taken care of by four high level oil burners which together with their lighters are mounted on the front wall of the boiler at an elevation about 10 ft. below the superheater tubes. These lighters are gang operated by remote manual control from the boiler operating console. From this location they can be projected into the furnace or withdrawn by air operated pistons, which in turn are controlled with electrically operated solenoid valves. As an operational safe-guard to prevent explosive mixtures of unburned oil and oil vapours from collecting in the boiler setting, each lighter is provided with a flame failure detector to warn the operator should a flame failure occur.

These burners are steam atomized and have a controlled firing rate which is adjustable from the boiler control console. As a further aid to controlling steam temperature,

Fig. 6. A view of the furnace front wall showing the re-entrant throats mounted side by side. Note slag tap opening.

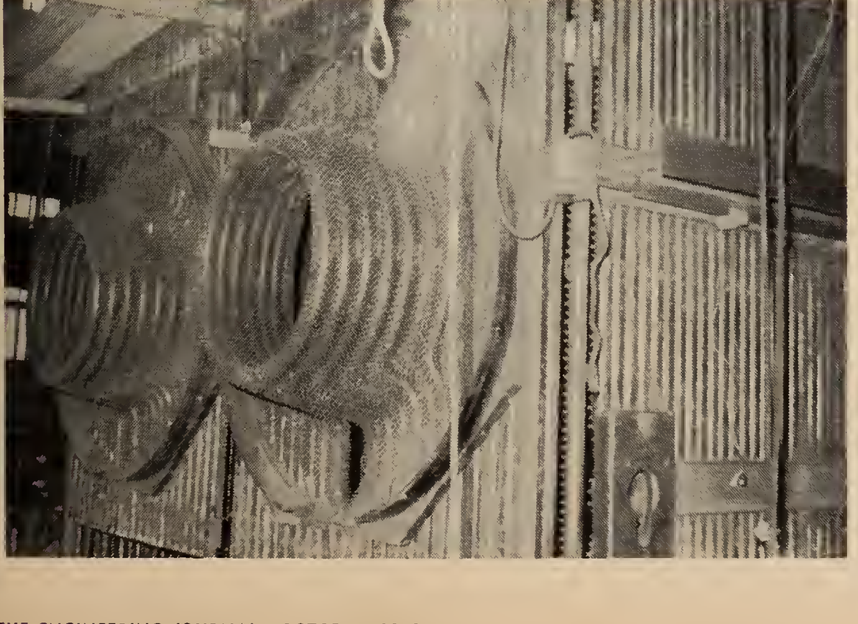


Fig. 7. A view of Steam Drum showing stub tubes projecting.

thermocouples are attached to the outlet ends of the secondary superheater tubes. A 24 point quick reading scanner records the tube metal temperature on a strip chart and also sounds an alarm should the temperature rise beyond a predetermined value.

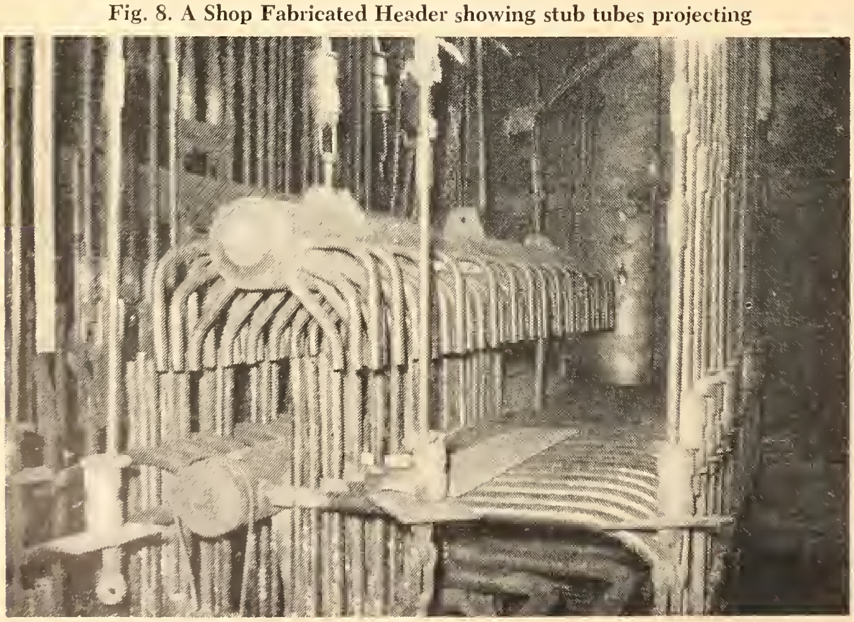
When the high level burners are in service it has been the practice to install portable thermocouple probes to measure and record the temperature of the gas entering the superheater. At present the chore of inserting and withdrawing these probes requires a boiler operator or an assistant. However, consideration is being given to providing retractable probes that can be inserted or withdrawn from the boiler console panel.

Pressure Casing

As previously stated these cyclone boilers have been designed for pressure firing; thus the forced draft blowers must provide all of the static pressure requirements for both the air and gas sides of the units, and all parts of the boiler casing are under pressure up to the stacks. Infiltration of air into the boiler setting is eliminated which results in a smaller volume of gas discharging to the stack with a corresponding reduction in heat loss.

Since these units operate under pressure they must be provided with a pressure-tight casing to prevent the escape of hot gases into the boiler room. This pressure-tight casing is made up of 10 gauge plate welded against the furnace and boiler tubes in such a way as to make a gas tight barrier. Construction details are such that ample allowance has been provided to take care of relative expansion. The exterior hot surfaces of the boiler are covered with an appropriate thickness of suitable insulating material to reduce heat loss to reasonable limits.

Fig. 8. A Shop Fabricated Header showing stub tubes projecting



Water Column TV and other water level indications

All operating personnel recognize the prime importance of close feed water control and the necessity of maintaining proper water level in the boiler at all times. Because of the importance of water level it is customary to have at least two and often three or more independent water level indications available to operating staff. These boilers have a water column with gauge glass mounted at both ends of the steam drum, and an instrument indicating and recording drum water level at all times. High and low alarm contacts have been incorporated in this instrument which in case of an abnormal water level condition initiate a flashing light signal on the enunciator panel and also sound an alarm.

In addition closed circuit television has been incorporated to show water level on a TV screen mounted on the boiler instrument panel. To give still further protection one water column on each boiler has been equipped with a high and low water level float mechanism, which for an abnormal water level condition blows a whistle and closes the contacts on a mercroid switch. These in turn initiate a flashing light signal on the enunciator panel and at the same time sound an alarm at the control panel. From the point of view of continuity of service the TV equipment has not been trouble free but rather has required some modifications and a considerable amount of maintenance. However, the operators do like this TV feature and it is considered a very desirable piece of equipment.

Secondary Air Port Oil Burners

The secondary air port oil burners, as is implied by their name, are installed through the front of the cyclone furnace and located in the secondary air port inlet as illustrated in Figure 9.

Due to their location they are cooled by the stream of high velocity secondary air flowing past them, and therefore can be left in position at all times regardless of whether coal or oil is being burned. In this location the oil burner is ready for immediate use in an emergency and can be put into operation very quickly.

These burners are rather simple in construction and are made up from a section of ¾ in. Type 310 stainless steel pipe or tubing; one end of which is plugged off and the pipe drilled along one side with a series of ⅛ in. holes to direct the bunker "C" oil into the furnace. No attempt is made to atomize the oil, since the velocity of the combustion air and the temperature of the cyclone furnace sufficiently accomplish this.

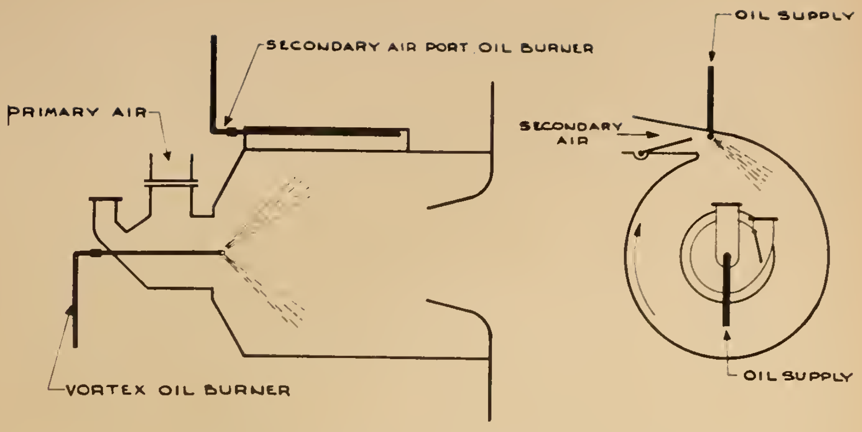


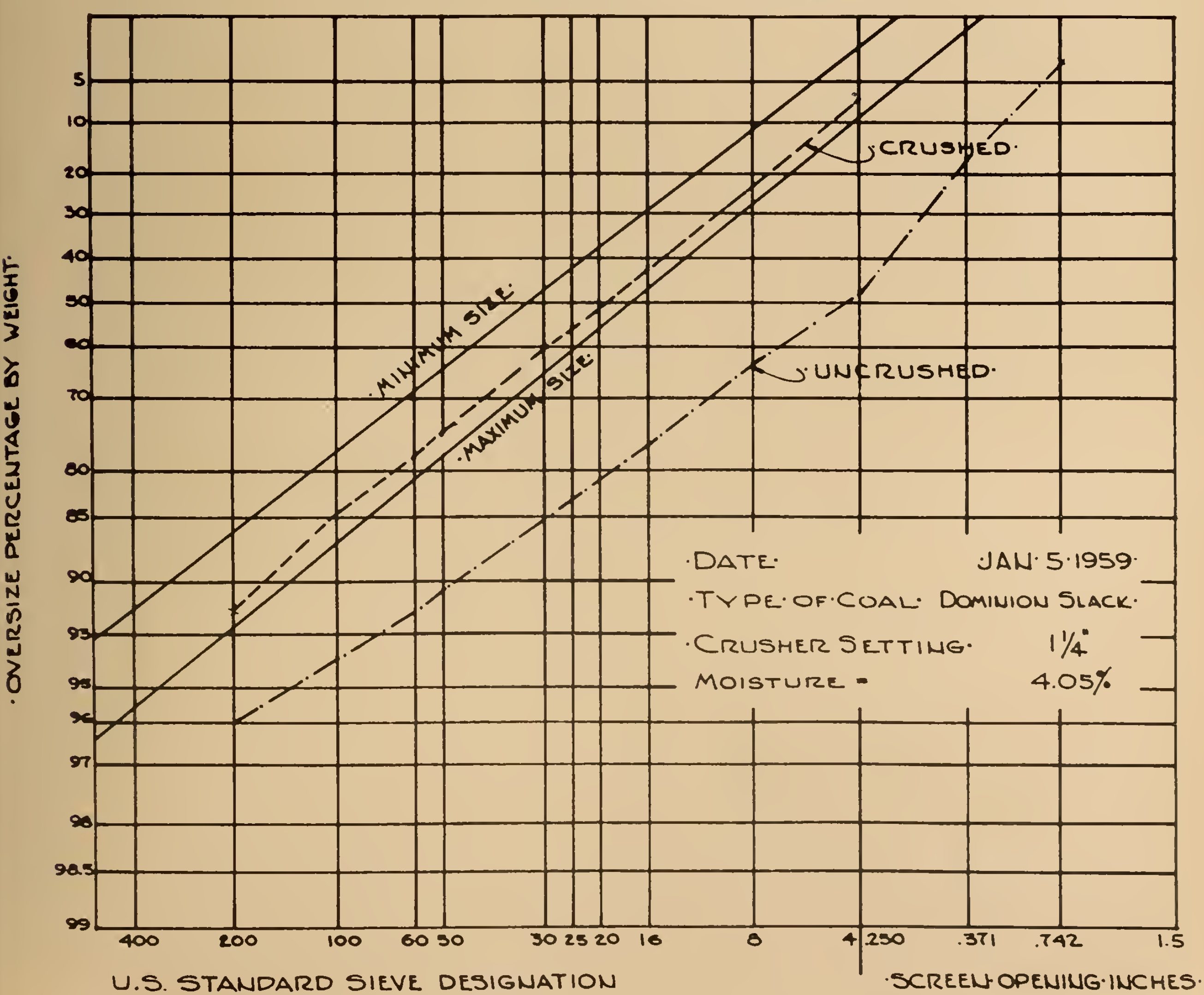
Fig. 9. Two Types of Cyclone Furnace Oil Burners.

Fuel — Coal and Oil

Bunker "C" oil and Nova Scotia coal provide alternate sources of fuel for this plant. The oil deliveries are normally made by harbour fueling lighters and pumped directly into two oil storage tanks which have a combined capacity of 30,000 barrels. Space is available for an additional oil storage tank if this is found to be necessary.

The importance of oil as an alternate fuel cannot be too strongly emphasized due to the very limited coal

Fig. 10. Chart of Typical Sieve Analysis of Crushed Coal.



storage facilities at the plant site. Apart from a small coal storage silo having a capacity of only 2,000 tons, the only storage available is in the coal bunkers for the various boilers. For the most part the bunkers are sized to hold about 2 days' supply with the units operating at full capacity. Should the daily coal deliveries be interrupted for any reason there is no difficulty in converting to oil.

Coal which until a few years ago was delivered by water transport, is now delivered by rail. Due to local conditions namely, the relatively short rail haul and the fact that fewer handlings are required, this method of delivering has been found to be more economical than water transport.

All coal is delivered to the plant by rail in hopper bottom cars and unloaded into a track hopper. From here it is taken to the various bunkers by a series of belt conveyors having a rated capacity of 200 tons per hour.

On the way to the bunkers the coal passes through a rotary hammer mill type of crusher where it is reduced in size to give a graded product, 95% of which should pass through a No. 4, or ¼ in. size screen.

The boiler manufacturer has recommended that the coal for optimum firing conditions for the cyclone units should conform with Table III.

Fig. 10 shows a typical sieve analysis of a sample of crushed coal.

Coal Feeders

Fig. 11 shows the general arrangement of the coal feeder equipment between the bunkers and the cyclone furnaces (2 per boiler) which consists essentially of the following:

(1) A motor operated upper coal valve;
(2) A drag type coal feeder with variable speed drive, and a separately driven coal distributor;
(3) A motor operated lower coal valve.

All of these items of equipment are electrically driven and are controlled from the boiler control panel.

To protect the equipment and prevent plugging of the coal feeders it is essential that they be operated in a definite sequence. To insure that the proper sequence is followed the equipment is electrically interlocked as follows:

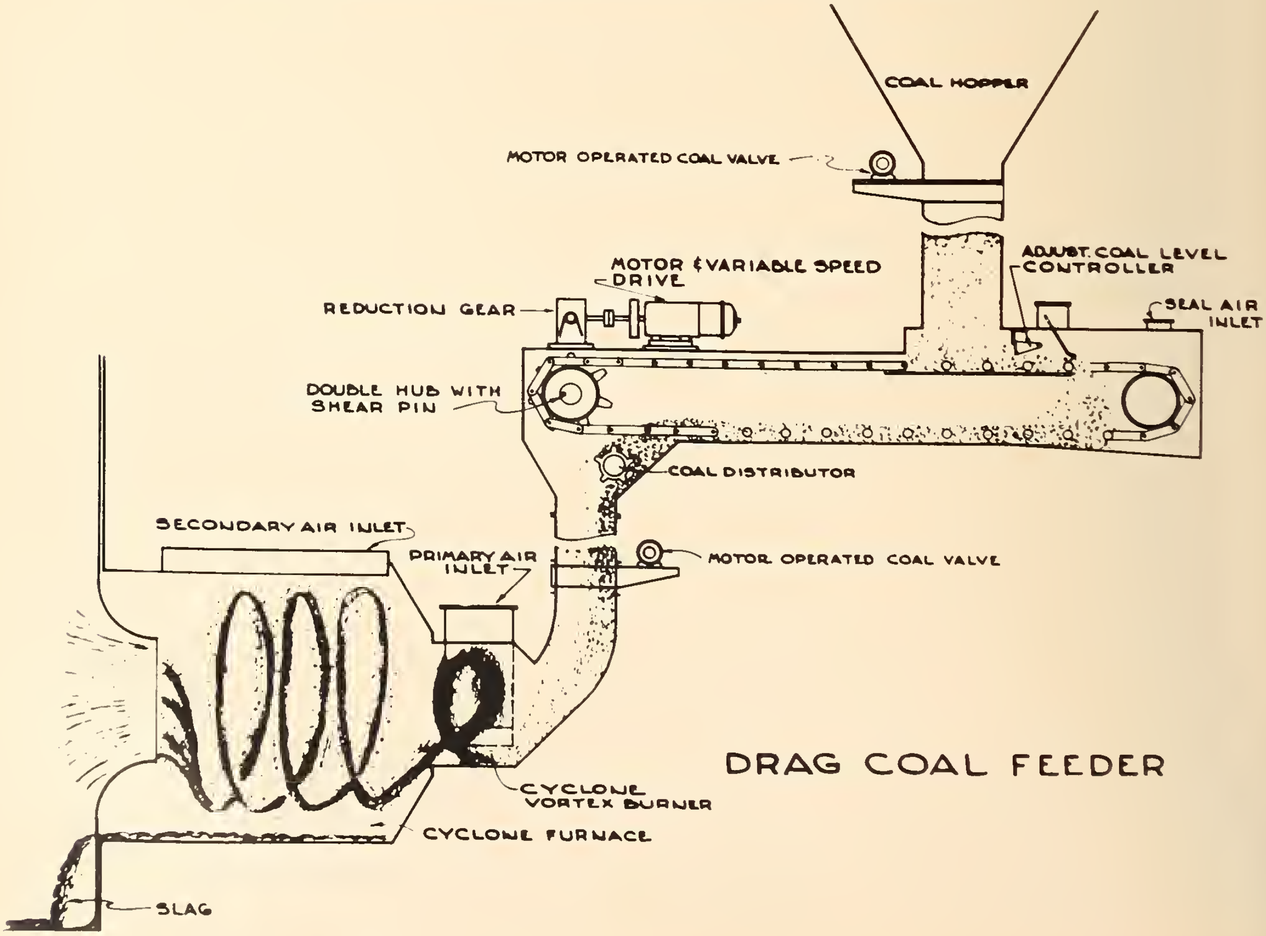
(1) A forced draft fan must be operating before a lower coal valve can be opened;
(2) A lower coal valve must be open before its corresponding coal feeder and distributor motors can be operated.
(3) Closing a lower coal valve shuts down the feeder and distributor motors;
(4) Loss of both forced draft-blowers shuts down the feeder and distributor motors and also closes the lower coal valves.

TABLE III

Screen No.	*% Passing*
4	95
8	85
14	70
28	50
48	30
100	20
200	10

In operation the speed of the drag type coal feeders which are driven through a magnetic clutch arrangement followed by a reduction gear can be controlled either automatically or manually from the boiler control panel. As an aid to the operators in regulating the coal feeders, speed indicators have been provided to in-

Fig. 11. Coal Feeder arrangement between bunkers and Cyclone Furnace.



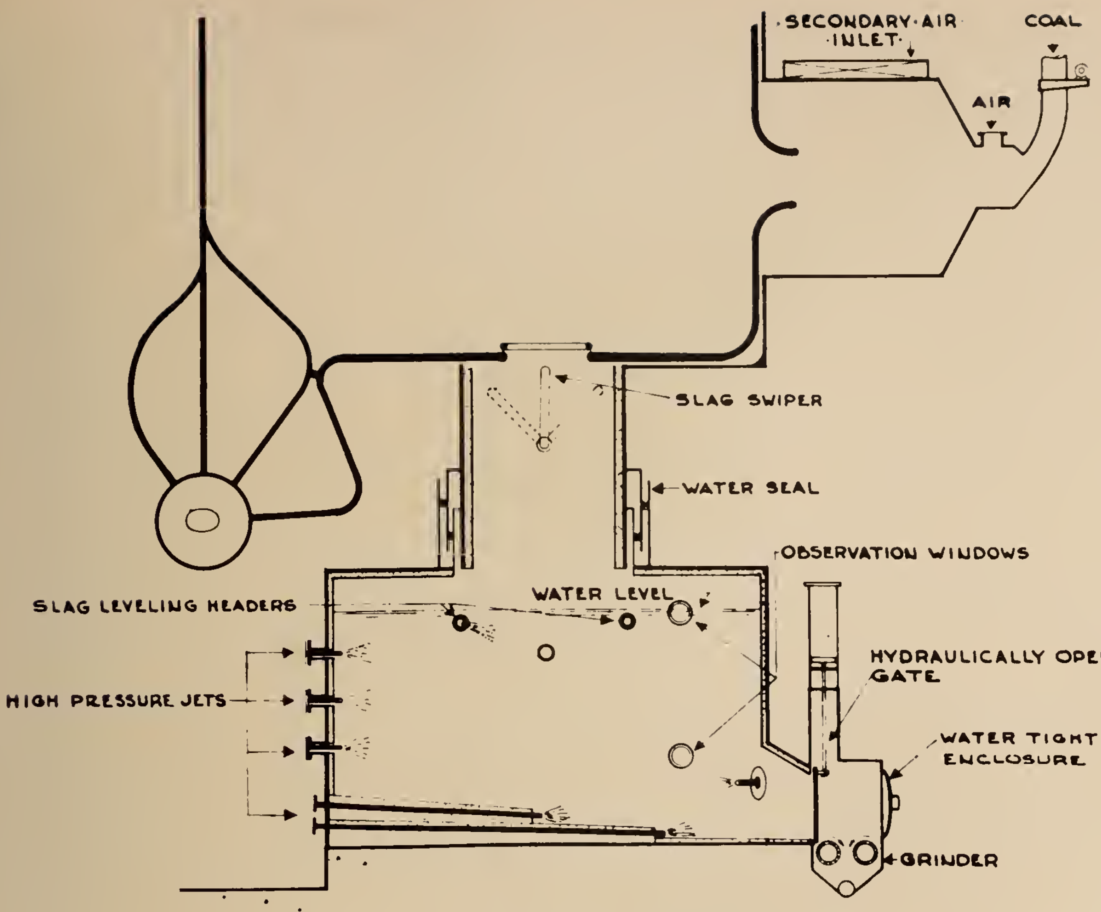


Fig. 12. Slag Tank Arrangement.

dicate the input speed to the reduction gear drives. In addition indicating lights have been provided to show the position of both the upper and lower coal valves.

One drag type feeder is used to supply coal to each cyclone, at a controlled rate in accordance with load requirements. The top flight of the drag feeder chain undercuts the column of coal flowing down the coal chute from the bunker. The movement of the drag feeder chain carries the coal toward the rear of the feeder passing under a levelling plate which is set to maintain a given depth of fuel and thus provide a uniform flow.

After passing under the levelling plate, the coal falls to the bottom of the feeder and is moved by the bottom flight of the chain to the discharge point. The fuel rate is determined by the speed of the drag chain which is controlled from the boiler operating panel. A motor driven rotary coal distributor is located in the discharge end of the coal feeder housing to assist in providing a uniform flow of coal by eliminating any avalanching tendency with dry coal or pulsating feed with wet coal.

Ash Handling System

Approximately 85% of the ash from the coal burned is collected in molten form and discharged to the water filled slag tank, which is shown schematically in Fig. 12.

This quantity represents the combined result of the slag collecting ability of the cyclone furnaces and the primary furnace. It follows that since combustion is virtually completed in the cyclone furnaces, the largest portion of the slag is therefore produced in the cyclones. The molten slag layer is continually added to as the incoming coal is burned out, and since the thickness of the slag layer tends to remain constant for uniform conditions of load, the excess slag flows to the rear of the cyclones and drains through a tap-hole to the primary furnace. From here the molten slag flows through a slag spout opening in the furnace floor to be collected in the water filled slag tank.

The molten slag on striking the relatively cold water is quickly chilled and breaks up into granular particles about the size of split peas or smaller. These granular particles have a vitrified appearance; they are shiny jet black in colour and have sharp corners.

The storage area in the slag tank of approximately 720 cu. ft. is designed to hold about 12 hours' accumulation of slag with the boiler operating at rated capacity. To distribute the slag evenly in the tank and prevent it from building up in a cone, two slag levelling headers having a series of high velocity water jets have been provided. Salt water, pumped from the harbour, is supplied to the headers which are located about 3 in. below the surface of the water in the tank, thus the high velocity jets keep the water very turbulent, preventing the surface water from becoming hot and at the same time encouraging disintegration of the slag.

The accumulated slag is removed from the tanks on a once per shift basis. Its removal is accomplished by a hydro-ejector arrangement which sucks the ash and water from the slag tank outlet. Salt water, pumped from the harbour, at the rate of 1300 U.S. g.p.m. and delivered to the hydro-ejector nozzle creates a vacuum for the ash removal operation.

The mixture of slag and water is delivered to either one of two hydrobins where the ash and water are separated. The slag falls to the bottom of the hydro-bins and the water builds up to the overflow level running to waste. Each hydro-bin has sufficient capacity to hold the slag produced over a 48-hour period by one boiler, operating at continuous full load.

Some of the Early Operating Problems and how they were overcome

During the initial stages of operation of the first cyclone fired unit, operation was attempted only during the day time and the unit was shut down each evening. This was partly to gain experience in starting and shutting down the plant and partly to insure that the plant was run only when there was close supervision by technical staff. In addition, it was necessary for the operating staff to gain some operating experience and become familiar with the new equipment before the burden of its safe operation could be placed upon them.

Acid Cleaning

The original plan was to operate the plant on medium loads for several months before acid cleaning the boiler. However, subsequent events changed this program. After about a week of intermittent operation of the boiler a leak developed in one of the 1½ in. O.D. cyclone furnace tubes. Investigation revealed that circulation was restricted in this tube due to blockage by foreign matter in the form of a gravel stone or pebble lodged in the inlet end of the tube. As a result of this discovery a very close internal examination was carried out of all boiler parts, particularly of all cyclone headers and tubes. A considerable quantity of foreign material was found which somehow had escaped detection during the preliminary boil out and clean up of the unit. In addition to the foreign matter, rusting and rust deposits were considered to be excessive, particularly in the two cyclone furnaces and, on the basis of this rust condition, it was felt necessary to acid clean the unit before attempting any further operation. The prearranged date for the official plant opening was now only three weeks away and—still more important — the additional capacity was needed to take care of system load requirements. The acid cleaning job was therefore commenced as soon as possible.

The cleaning job itself, which was carried out with utmost speed and under close supervision, went very well and good results were obtained in so far as removal of the rust coating was concerned. However, the acid cleaning resulted in other unforeseen difficulties developing and really proved to be the "acid test" since a series of leaks occurred following the acid cleaning. Without exception, the leaks occurred at welded joints in the boiler tubes. As near as could be determined, these leaks were due to the removal of small slag inclusions in the welded joints. In themselves the leaks were small and not too serious, however, the actual repairs ran into several time consuming operations since it was necessary, in each case, to cool down the boiler and drain the unit before repairs could be carried out.

Slag Removal

During the first weeks of operation, difficulty in removal of slag accumulations from the slag tank caused some concern and prevented continuous operation of the boiler. A number of forced outages were necessary in order to empty the slag tank and also for the purpose of carrying out various design changes and adjustments of the equipment. The general arrangement of the slag tank is shown in Fig. No. 12 which was referred to earlier.

During the slag removal operation, the hydraulically operated door is opened to permit the flow of water and slag from the tank to the water tight enclosure from where it passes through the clinker crusher, to be picked up by the hydro-jet and delivered to the hydro-bins. The agitator nozzles, located at various levels in the tank and designed to encourage the flow of slag from the tank, were not effective in complete removal of the slag. As water level in the tank dropped the pile of slag remaining would protrude above the water level; then the molten slag being continuously discharged to the tank would fall on top of the slag remaining and cause large clinker formations. Numerous arrangements of the agitator nozzles were tried with varying degrees of success. However, the final and complete answer to the difficulties was arrived at only after several months of operation. The solution proved to be the installation of 3 water jets in the floor of the tank, located in such a way as to undermine the pile of slag and carry it from the tank to the clinker crusher. As a further aid to operating personnel, two heavy glass observation windows were located in the side of the slag tank so that water level in the tank could be observed as well as the rate of ash removal. Slag removal has now settled down to be a straight forward and routine job, requiring 30 to 40 min. per shift.

Coal Feeder Troubles

The drag type coal feeders (which were described earlier under fuel handling) were responsible for some of the teething troubles during the early weeks of operation: the general arrangement of the coal feeders (2 per boiler) is illustrated in Fig. 11.

The top flight of the coal feeder chain in passing under the coal chute from the bunker, carries coal into the feeder. Most of this coal falls through the drag chain to the bottom of the feeder housing, however, a small quantity may stick to the chain links and be carried to the rear of the feeder. Chips of wood or foreign matter, which have got by the magnetic pulley on the coal conveyor system, often were carried to the rear of the coal feeder and then proceeded to wedge tightly between the drag chain sprockets and the bottom of the feeder housing. This results in the failure of a shear-pin which is designed to protect the feeder chain and drive from damage. Failures of this type happened so often that the bottom of the drag feeder housings were lowered to give greater clearance and thus prevent the wedging of small bits of foreign matter from causing a shear-pin failure. This was a step in the right direction and eliminated a great deal of the troubles. However, shear-pin failures still occurred, due to foreign material and other causes.

From the operational point of view shear-pin failures, resulting in loss of coal feed were looked upon as being very serious, particularly since the boiler operator would not know there was anything wrong until they started to lose steam pressure. By the time the operator located the trouble and determined which cyclone burner was out, it was often necessary to transfer 20 to 25,000 kw. of load. Needless to say, this type of failure suddenly caused large and undesirable pressure and temperature changes in both the boiler and turbine equipment. Alarms to indicate a coal stoppage to the feeders had been provided, however, they would not give an indication of a shear-pin failure.

A member of the operating staff came up with a very ingenious and simple idea to indicate a shear-pin failure. Since these new alarm indications have been provided, there has been a marked improvement in over-all operation. Should a shear-pin failure now occur, the operator knows immediately which feeder is in trouble, and since the secondary air port bunker "C" oil burners are always ready for use, the standard procedure is to switch over to oil burning immediately. A secondary air port burner can be brought on simply by opening one isolating valve. This change-over can be accomplished with little or no loss in steam pressure and without the necessity of reducing load.

Conclusions

The early months of operation of the cyclone fired units were not completely trouble free. However, the difficulties encountered, for the most part, have now been overcome and satisfactory solutions arrived at.

It was expected that, with this comparatively new method of burning coal, some initial teething troubles would be encountered, especially until such time as the operating staff had an opportunity to become familiar with the new equipment and had been trained in the new operating techniques.

A few of the early operating troubles have been discussed as well as how they were overcome. For the most part, operation has now settled down to be a routine job.

The following list records some of the observations made during the early months of operations of these cyclone fired units.

(1) The cyclone furnaces have proven to be well suited for burning most grades of Nova Scotia coal.

(2) The danger of furnace explosions for coal firing is eliminated, by the use of crushed rather than pulverized coal.

(3) The cyclone furnaces are suitable for operation with bunker "C" oil.

(4) The cyclone furnaces can be very quickly changed over from coal to oil firing as the secondary air port oil burner remains in position and ready for immediate use at all times.

(5) The maintenance cost of cyclone burners is considerably less than for pulverizer equipment. However, this saving is partly overcome by higher maintenance costs for the coal crusher hammers. Experimental work is still being carried out with various types of hammers, and with hardcoating materials to protect the hammer wearing surfaces.

(6) There is no dust problem involved in the handling and trucking away of the cyclone slag.

(7) On a few occasions, stack emission has been excessive due to faulty combustion conditions. and at other times, due to soot blowing operations. This matter is still under study.

(8) From an operational point of view, the boiler room staff like the cyclone units; they have found them easy and safe to start up and operate.

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POWER IN CANADA *(Continued from page 62)*

pacity of 65,920 h.p. (end-1957).

United Towns Electric Company Limited is constructing a 1200 h.p. single-unit hydro plant at Pitmans Pond, New Chelsea Brook.

Iron Ore Company of Canada is expected to add a single 19,000 h.p. unit in 1960 to the existing development at Manihek Rapids, Ashuanipi River, in Labrador. Present capacity is 12,000 h.p.

British Newfoundland Corporation Limited and its subsidiary companies do not at present have any electric generating capacity, but they have water-power rights on about half the undeveloped rivers in Newfoundland, and on virtually all of the rivers in Labrador. The Hamilton River, in Labrador, has a proven potential of 4 million h.p. at one site and an estimated 2 million h.p. at other sites downstream.

At Bay d'Espoir, on the south coast of Newfoundland, there is a proven potential of 350,000 h.p. at one site. The Corporation plans to complete construction at this site of the first stage of 70,000 h.p., in two units, by 1962-3. Further stages, each of a single 70,000 h.p. unit, would be added as required to meet demand. Initial plans are to build transmission lines at 161 kv. from Bay d'Espoir to Grand Falls and Whitbourne.

Hamilton River power can be developed most economically by the "Channel Scheme", which would have a total installation of at least 4 million h.p. in a single powerhouse under a head of 1050 ft. Because of the difficulty of marketing such large blocks of power, various subsidiary schemes have been surveyed in the Hamilton watershed. These would enable demands of 50,000 h.p. to nearly 500,000 h.p. to be met. Initially it may be necessary to build one of the subsidiary schemes to meet local demand, and results are expected from negotiations with several potential customers, including mining interests in Labrador.

WHITE DOG FALLS

(Continued from page 84)

rock, some of which was under water. All equipment was transported to the site 17 miles by barge. This included compressors, 2½ yard draglines, heavy tractors and trucks, as well as necessary camp equipment and supplies. Where the rock to be removed was under water, staging was built and drilling was done through boiler pipes set in the rock. The work was carried out in three sections. First the upstream section, then the downstream, and finally the centre section. In carrying out the excavation in this manner, nearly all dragline work was in still water and a barrier was maintained across the new channel until the greater part of the rock was excavated. The underwater blasting was successful except for a small section near the upper end of the channel. This section was subsequently redrilled from a barge and blasted. The broken rock was later removed by clamming. The rock channel broke exceptionally smooth and the loss of head through the Boundary Falls reach is now only about 6 in.—it was formerly about 3 ft. 6 in.

Both projects were designed by the Ontario Hydro Engineering staff and constructed by the Ontario Hydro Construction Division.

138 kv. UNDERSEA CABLE ACROSS GEORGIA STRAIT

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THE COMPLETION of the submarine cable link between the lower mainland of British Columbia and Vancouver Island has been called a landmark in the development of submarine power transmission. This paper describes the basic considerations leading to the adoption of the 138 kv. interconnection, and the design, manufacture and laying of the cables.

The first circuit with five cables was completed in the summer of 1956. In 1958 an additional two cables were installed to provide two circuits, each capable of transmitting 120 Mw. with one cable as a spare. It is estimated that the cable link will be sufficient to meet the needs of the south Vancouver Island service area of the B.C. Electric Co. Ltd. until the late 1960's.

The British Columbia Electric Company Supply System

The service area of the British Columbia Electric Company shown in Fig. 1 covers the south western mainland of British Columbia and the southern part of Vancouver Island. The mainland of British Columbia is well endowed with indigenous power resources. It is estimated that more than 15,000 Mw. of hydro power still awaits development, while natural gas from the Peace River district is now available in the lower mainland. By contrast, the area served by the B.C. Electric Company on Vancouver Island contains no new hydro electric sites suitable for development. Furthermore, while the northern portion of Vancouver Island still has some undeveloped water power, it is anticipated that this will be needed to meet the region's own increasing electrical demands.

From load studies made several years previously, it had become evident that an additional source of power for the southern part of Vancouver Island would have to be provided during 1956. Actual and predicted one hour peak loads for the B.C. Electric Company's Vancouver Island system are plotted in Fig. 2 for the period from 1945 to the present time, with projected loads to 1970. This curve shows that during the past ten years an average load growth of 10% per annum compounded has been realized. During the winter of 1955/56 the one hour peak reached 75 Mw. thus practically equalling the system peaking capability of 76.9 Mw. detailed in Table 1.

A serious need was also developing for additional reserve capacity. All four units of the Jordan River hydro electric plant are served by a single wood flume making them particularly vulnerable to simultaneous outage. Also the old Brentwood steam plant contained 12 Mw. of inefficient units, some of which were due for retirement.

From Fig. 2 it will be seen that another 120 Mw. of electrical power would be needed over the subsequent six or seven years, allowing for the anticipated termination of contracts for purchased power.

Alternative Sources of Supply

Since additional purchased power from hydro electric sources in the northern part of the Island was not available, consideration was given to an oil or coal fired steam plant, a nuclear power plant, and an a-c or d-c submarine cable interconnection transmitting mainland hydro electric power to the Island. The cost of power from a modern 120 Mw. steam plant operating on Bunker C oil or coal at 60% load factor was estimated at about 8 mills per kwh. including fuel, fixed charges, operating and maintenance costs. Nuclear plants of that size were neither sufficiently developed at the time nor economically competitive. It was estimated that the cost of mainland hydro electric energy delivered to Vancouver Island over a 120 Mw. a-c submarine cable interconnection would be about 80% of that obtainable from a modern coal or oil burning generating station. The unit cost of transmission over the cable link itself would be little over 1 mill kwhr. when operating at 60% load factor. High voltage d-c transmission was also considered but rejected as uneconomical, and the limited practical experience with converting equipment at that time was deemed insufficient to justify its adoption.

The a-c interconnection scheme had other advantages. One block of reserve capacity would suffice for both Island and Mainland systems. The hydro electric plant on southern Vancouver Island was dependent on the run-off of one watershed only. In wet years, water was spilled, while in dry years an energy shortage sometimes occurred. The interconnection would allow the co-ordinated and efficient use of several watersheds having diverse run-off characteristics both on the Mainland and on the Island. There was no doubt that the high voltage a-c interconnection scheme was both feasible and economically attractive. The decision was taken to go ahead.

Route Selection

A map of the interconnection route from Tsawwassen Beach on the Mainland via Galiano, Parker and Saltspring Islands to Vancouver Island at Sansum Narrows is shown in Fig. 3. To determine the best route, exhaustive hydrographic surveys were carried out, soundings and accurate sea bed contours were taken, bottom currents measured and bottom samples collected. The profile of the route finally adopted is shown in Fig. 4 with submarine conditions summarized in Table 2.

Between Vancouver Island and the Mainland are a number of long narrow islands rising steeply from the sea bed. Bottom conditions generally are rugged; part sand or gravel, part rock, with abrupt changes in contour, and deep holes. Fortunately a part of the channel between Tsawwassen and Galiano was found to be covered with silt from the Fraser River, and offered a flat soft bottom except for a ridge of rock about two miles off the shore of Galiano Island. The cables take this route, and with the permission of the U.S. authorities pass through U.S. territorial waters for a distance of about 7 miles.

The channels between Galiano, Parker, Saltspring and Vancouver Islands are much less attractive from the cable laying point of view. However, a detailed survey of Trincomali Channel between Parker and Saltspring Islands revealed a small section which was satisfactory, involving a short 2.6 mile crossing. For the mile wide crossing of Sansum Narrows between Saltspring and Vancouver Islands an overhead span was utilized.

Ships anchors and trawling provide potential hazards to the cables in the congested coastal shipping lane. With the co-operation of the Department of Fisheries beam trawling was prohibited in Trincomali Channel but no trawling restrictions were imposed in the Strait of Georgia. To minimize the danger of damage from ships anchors, cable routes and landing sites were kept well clear of good anchorages.

Scheme of Development

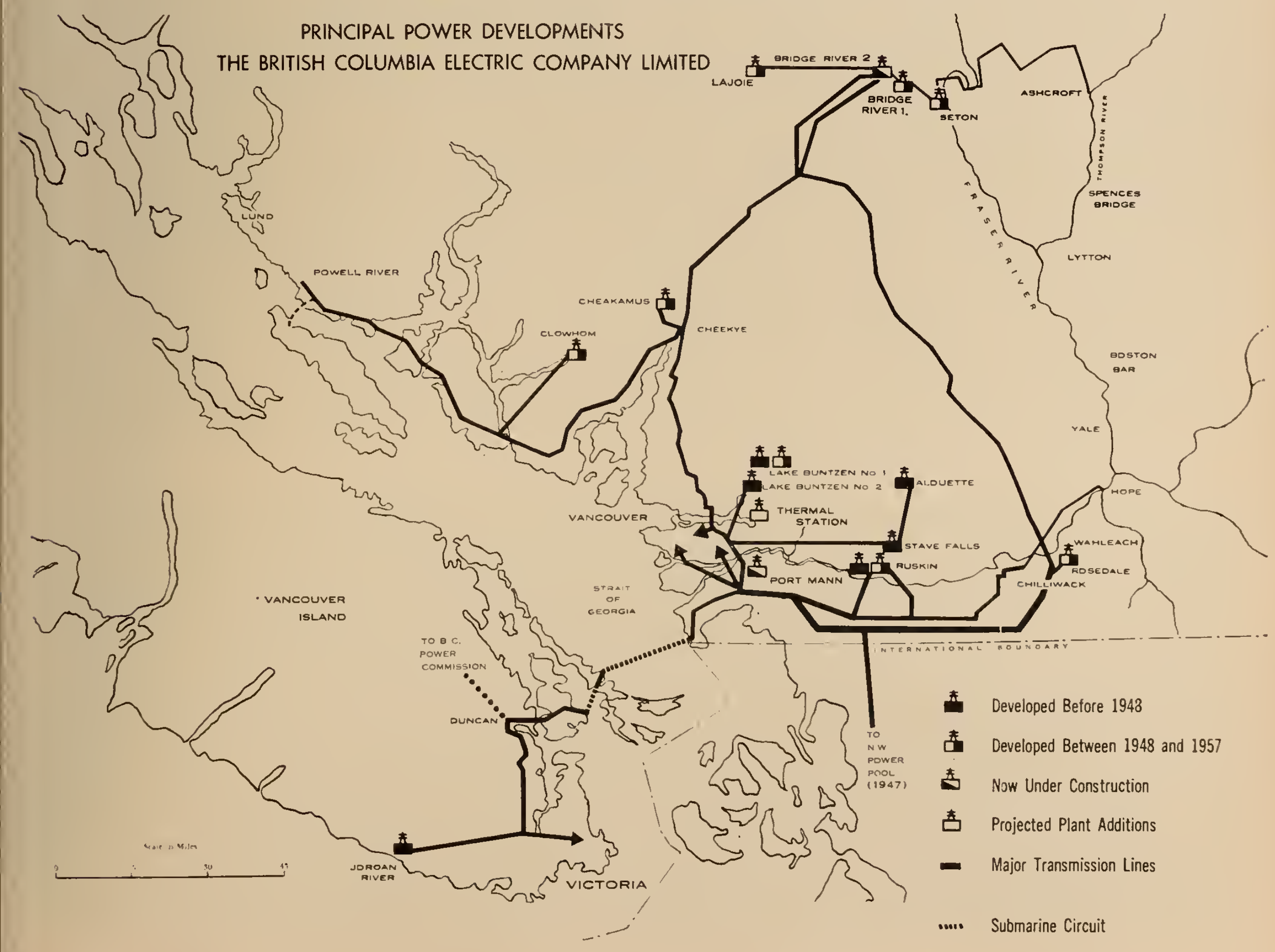
Under the first stage of the development in the summer of 1956 five submarine cables were laid across the Strait of Georgia and five across Trincomali Channel. Four of these cables were connected to the four conductors of the 138 kv. overhead line sections of the link. Three cables were used for the single three-phase circuit while the fourth circuit could be switched at the terminal station to replace any faulty phase. The fifth cable served as an additional standby.

The second and final stage of this development completed in 1958 involved the laying of another two cable links and the provision of another overhead circuit. Thus there are now seven cables and seven overhead conductors comprising two 120 Mw. three-phase interconnections with one common spare circuit.

Protection and Control

Both terminal stations are unattended and controlled by supervisory carrier-current equipment from the load dispatch centres in Victoria and Vancouver respectively. Two-zone impedance relays are used for phase protection, and high-speed directional ground-impedance relays for ground protection. A single-zone impedance back-up relaying system is provided to guard against failure of the primary relays and circuit break-

Fig. 1. Principal Facilities of the British Columbia Electric Company.



ers. In the event of a phase-to-ground fault the circuit breakers at the terminal station are tripped, and the spare circuit is automatically substituted for the faulted phase using motor operated switches. The Mainland circuit breaker is then reclosed, and the Vancouver Island system is resynchronized if necessary either manually or automatically, from the load dispatch centre in Victoria.

Communication and gas pressure alarm facilities are provided through the co-operation of the British Columbia Telephone Company. The low gas pressure alarms are signalled at the telephone exchanges closest to the cable terminals. An audible alarm is given together with two signal lights for gas failure and one light for circuit failure. Alarm conditions are reported by the exchanges to the B.C. Electric Co. Load Dispatch Centres.

Cable Design and Manufacture

The decision was taken to manufacture the cable in continuous lengths,[1] even though this meant installing special plant for its manufacture and handling. It was agreed that the use of joints involved uncertainties which could only be justified under conditions of emergency, although both rigid submarine joints for jointing two sections of cable at sea, and reconstructed joints to be made at the factory had to be fully developed. As it transpired, both types of joint were needed.

The decision to adopt the single-core gas-filled type of cable using pre-impregnated paper insulation[2] followed logically, this being the only practicable type which lent itself to continuous manufacture and could be developed for the duty required.

Table I

B.C. Electric Company—Vancouver Island System

One-Hour Peak Capability—December, 1955

Source	*Type*	*Peak Capability*
Jordan River plant	Hydro-electric	26.4
Diversion plant	Hydro-electric	1.5
Brentwood plant	Steam (oil-fired)	12.0
Purchased power		37.0
		76.9

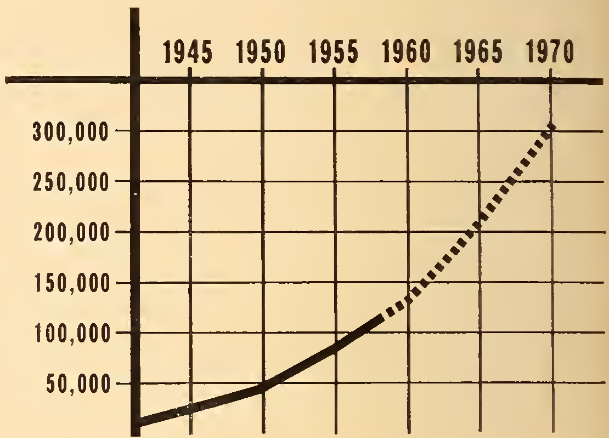


Fig. 2. British Columbia Electric Company — Vancouver Island System. Actual and Predicted One-Hour Peak Loads.

The cable was required to operate at 138 kv. 3-phase 60c/s, with a rating of 120 mva. The maximum external sea-water pressure would be 265 lb/in², and in order to prevent extensive ingress of water into the cable in event of damage, it was designed to operate at 300 lb./in² nitrogen gas pressure. Extensive laboratory tests followed by sea trials at approximately 100 fathoms, including laying, grappling and recovering the cable, led to the development of the final design summarized in Table 3 and illustrated in Fig. 5.

Meanwhile, the layout and design of the plant to manufacture the cable in continuous lengths was proceeding, with particular consideration being given to the methods of storing long lengths of cable between the various stages of manufacture. A diagram of the plant layout is shown in Fig. 6. Features of particular interest in the design and construction of the cable are as follows:

A. Conductor and Insulation

The cable was designed on the basis that all coiling would be in a clockwise direction. The outer layer of conductor wires was stranded right-hand, so as to contract in diameter under coiling, thus avoiding damage to the dielectric papers. The central duct was designed to provide the gas-flow channel; the clearance under the lead sheath, which is stan-

Fig. 3. Mainland—Vancouver Island Interconnection Route.

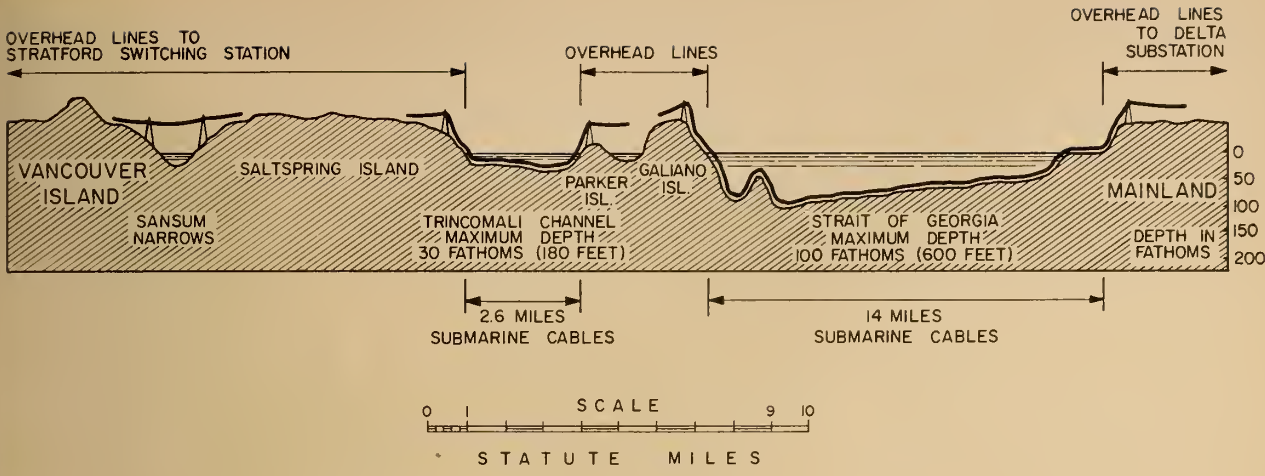


Fig. 4. Profile of Route.

dard practice in the case of land cables, is inadmissable, since at depths in excess of 40 fathoms the sheath would tend to deform under the external water pressure. Stranding of the conductor was performed on a standard floating-bobbin two-carriage machine.

The normal method of storing a long length of cable is to coil it on the ground, but this twists the cable through 360° for every turn of the coil. It was decided that twisting of the cable should be reduced to a minimum at every stage of manufacture except in its finished state, and that large power-driven horizontal turntables should be installed for coil-storing the cable between operations. A turntable was installed to receive and coil-store the conductor between the stranding and insulating machines. It was 24 ft. in diameter, designed to accommodate up to 25 miles of conductor of 1 in. diameter, and driven through an electronically-controlled magnetic coupling giving constant speed at any load. Owing to the difference in speeds between coiling down from the stranding machine and paying-off into the insulating machine, the drive was fitted with two gears and a 2-speed motor.

Insulating papers were applied with graded thicknesses and tensions in four reversed-lay sections by means of a rotating-cage type lapping machine of special design. As the paper applied to the cable was pre-dried and impregnated, special measures were taken to eliminate contamination and to control the moisture pick-up during any enforced long stoppages of the machine. The insulating machine was therefore fully enclosed with a drying plant to maintain the atmosphere within the enclosure at uniform humidity, which could be reduced to 3-4% in the event of a prolonged stoppage.

B. Alloy-Lead Gas Retaining Sheath

Alloy E was adopted for the gas retaining sheath, after careful study of the properties of alternative alloys, primarily because of its high fatigue resistance. The sheath was extruded on to the insulation by the lead press with a shrinkage of 30-40 mils diametrically to obviate distortion under external water pressure while the cable was being laid.

To allow continuous manufacture, it was essential for the plant to run continuously for 500 hours or more. From this aspect, the most vulnerable point in the whole production line was the lead press, where a stoppage of ten minutes would so damage the cable as to necessitate cutting it out. As a safeguard, the pumps and control console were duplicated, any necessary change-over being possible within a few minutes.

A special gamma-ray photographic unit was developed for measuring regularly the sheath thickness at four positions at right angles to each other, without interruption of production. The gamma-ray source was 2 curies of cobalt 60 in a heavily screened container with a remotely controlled shutter.

Since it was impracticable to synchronize exactly the insulating machine and lead press, an accumulator system was designed and installed between the two machines to store 130 yd. of cable. This enabled the lead press to run for up to three hours at normal production speed with the insulating machine stopped. In an emergency the lead press could run for up to 20 hours at reduced speed should a breakdown of the insulating machine require it. The accumulator consisted of a large 8-fall pulley system mounted horizontally. All the pulleys were 15 ft. in diameter and the spans of cable between the pulleys were supported by a system of rollers. A second turntable, 47 ft. in diameter was installed between the lead press and the reinforcing machine to accommodate up to 25 miles of cable.

C. Reinforcing and Armouring

The application of the reinforcing tapes, vulcanized-rubber anti-corrosive sheath, bedding, steel-wire armour and serving was carried out in tandem in machines driven from

Table II Summary of Submarine Conditions

Item	*Strait of Georgia*	*Trincomali Channel*
Length of Cable section	14.7 miles	2.9 miles
Maximum depth	100 fathoms (600 feet)	30 fathoms
Bottom conditions	Generally sediment, but with a ridge of rock parallel to and at a distance of 2 miles from shore.	Generally sediment
Peak of ridge	Ridge rises from 100 fathoms to 40 fathoms at the peak, and falls to 80 fathoms on the Galiano Island side.	
Currents	Surface: 4 knots average. Bottom: 1 knot maximum.	
Corrosion	No corrosion conditions due to organic or chemical sources.	
Marine life	No teredo present.	

a common backshaft.

The reinforcing tapes were applied with a right-hand lay (i.e. opposite-hand to the armour) in three layers, so that, under the tensile loads experienced during laying, their circumferential torque was opposed to and practically equal to that of the armour. This substantially reduced any tendency of the cable to throw loops on the sea bottom under certain conditions of laying and recovery.[3]

The anti-corrosion sheath, which protects the reinforced gas-retaining sheath against corrosion, consists of a homogeneous and fully vulcanized sheathing of natural rubber compound. It provides adequate insulation against the transient voltages approximately 10 kv.) which may be induced between the armour and the gas-retaining sheath in service.

After vulcanizing, the rubber sheath was tested at 20 kv. by two-spark testing units in tandem. These were interlocked so that voltage was applied only when the cable was moving. Failure of the rubber sheath automatically stopped the armouring machine to allow inspection and repair to be made.

Steel-wire armouring comprised galvanized steel wires applied with a left-hand lay to avoid locking during clockwise coiling. The optimum lay was determined, by experiment, as 12 times the pitch-circle diameter, to provide the desired coiling and handling properties consistent with minimum torsion under the tensile loads of laying. Much work was done on various aluminum alloys with the object of reducing the electrical losses in the armour. Although their normal electrical and mechanical properties were satisfactory, it was found that, under water, the abrasion resistance was much inferior to that of steel, and for this reason the use of aluminum wire armour was rejected and galvanized steel was adopted. The cable was transported from the capstan of the armouring machine by overhead gantry and coiled in the coiling shed in readiness for loading on to the cable ship.

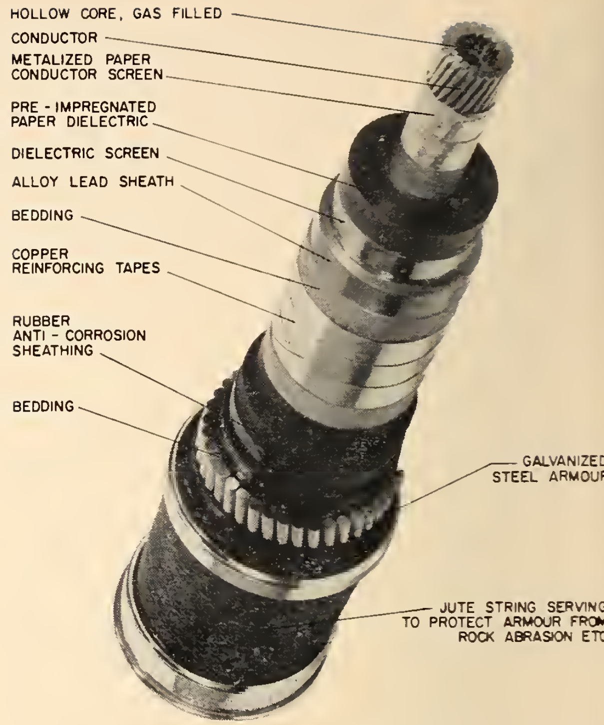


Fig. 5. Construction of 138 kv single-core gas filled cable.

D. Quality Control and Tests

It was not practicable to test the cable under high voltage a-c. conditions and full gas pressure, either during or on completion of manufacture, owing to the length involved and to the fact that full gas pressure could not be applied without impairing the flexibility and handling properties of the cable before laying. Consequently, rigid quality control and inspection at all stages was essential. High voltage d-c. tests and pneumatic tests at reduced gas pressure were carried out on the full lengths of cable in the lead-sheathed stage (No. 2 turntable) and the finished stage (coiling shed). At the start and finish of each length manufactured, lengths were cut off for complete testing and dissection to confirm compliance with the specifications. Performance tests include electrical stability, voltage surge, bending, coiling, and tests under external water pressure and internal gas pressure.

Cable Installation

A. Shipment

The five cable links comprising the first stage of development were shipped to site and laid by the cable ship "Ocean Layer".[4] This ship of 4,600 tons displacement had recently been completely fitted out with the most modern equipment and gear, and with an experienced captain and crew proved very suitable for the difficult job of installation.

Cable was loaded into the tanks of the "Ocean Layer" by a specially constructed overhead gantry 350 yd. long at a speed of about 800 yd. per hour. Fully loaded with approximately 3,900 tons of cable the "Ocean Layer" sailed for Vancouver and commenced laying operations there on the 16th of July 1956. For the second stage of the development in 1958, the unavailability of the "Ocean Layer" led to the charter of "H.M.T.S. Monarch", the largest cable ship in the world. Procedures developed for the first installation were utilized throughout and the cable laying operation followed a virtually identical pattern.

B. Landing Sites

Detailed surveys were made of the waters and bottom conditions surrounding the landing points. Storm records over a period of years were examined, and it was established that the effect of wave action could be adequately restrained.

The three island terminals of the submarine cable route are broadly similar, lying in small indentations on rocky coastlines with sufficient depth for the cable ship to anchor about ¼ of a mile off shore in 15-25 fathoms. After clearance and grading of these inlet sites, reinforced concrete cable chases were constructed from 5 ft. below low water to the pothead sites some 50 ft. above high water mark and 300-400 ft. distant. These were subsequently covered with concrete slabs. Additional protection for cables exposed at low tides was achieved by sleeving them with split articulated protectors of malleable cast iron.

The Mainland terminal at Tsawwassen Beach presented special problems since it had a sea approach over about 1½ miles of sandy shallows and on land a steep unstable bluff rising to a height of about 180 ft. This bluff was cut to a depth of about 30 ft. to reach a competent layer and a concrete cable subway 450 ft. long furnished with steps and cable racks was constructed leading to the potheads some 900 ft. from the high water mark. On completion the cut was filled and replanted to reduce the risk of subsequent movement.

C. Laying from the Cable Ship

The greater part of each cable was laid from the cable ship using established methods. To avoid the risk of looping or kinking the cable it was decided to lay it with a small residual tension on the sea bottom. The position of the touch-down point of the cable was calculated in relation to the position of the echo sounder in the ship, the shape of the suspended cable and the tension required at the dynamometer on the deck, to maintain the desired residual tension in the cable on the sea bottom. During laying, extensive records were kept from which it was confirmed that the cables had been laid closely in accordance with the planned requirements. Speed of laying was limited to approximately 3 knots which was considered the maximum at which the cable could safely be handled out of the hold and through the ship's machinery. During cable laying, the ship's navigating officers plotted her position at 4 min. intervals using suitably positioned markers on land and, in the Straits of Georgia, additional marker buoys with radar reflectors previously laid by the ship. Laying proceeded without incident except for one Trincomali Channel cable when the ship was carried at right angles to the route by an unexpected rip tide near Parker Island: the cable under heavy tension was bent to a radius of 15 in. around the bow sheave flange, and visibly flattened. During d-c. testing after laying the cable failed at this point and a submarine repair joint was inserted.

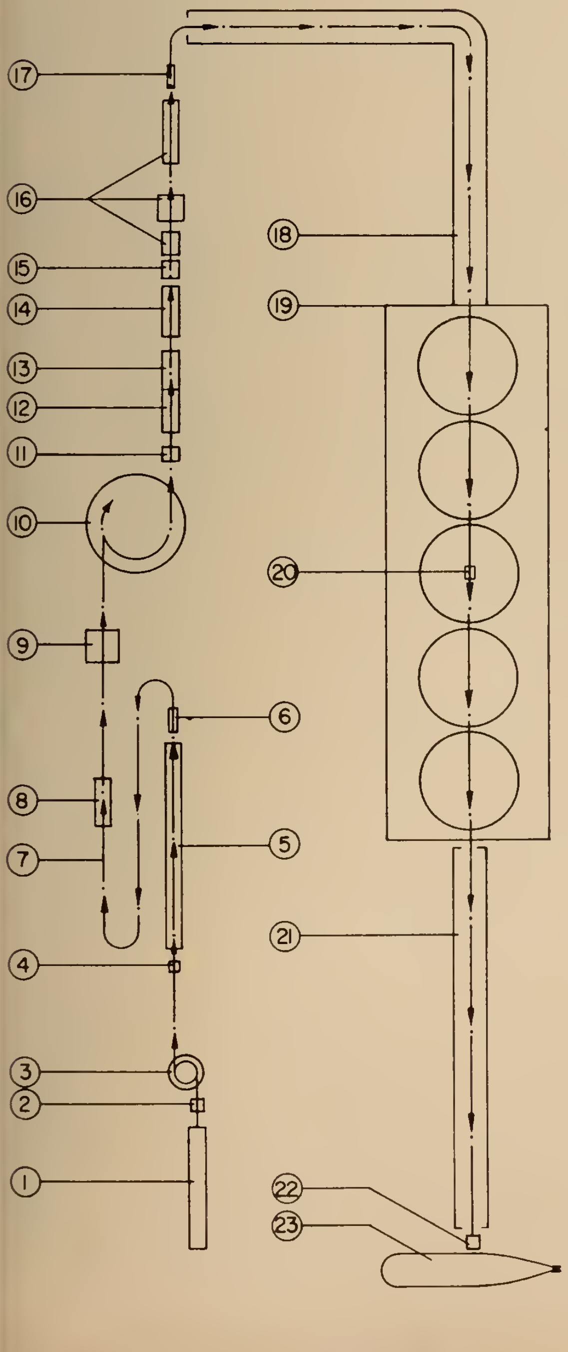


Fig. 6. Diagram of Manufacturer's Plant Layout. 1. Stranding machine. 2. Caterpillar haul-off. 3. No. 1 turntable. 4. Caterpillar brake. 5. Insulating machine in enclosure. 6. Capstan haul-off. 7. Accumulator system. 8. Accumulator output capstan. 9. Lead press. 10. No. 2 turntable. 11. Caterpillar brake. 12. Reinforcing tape heads. 13. Rubber taping heads. 14. Vulcanizer. 15. Spark testers. 16. Jute bedding, wire armouring and serving machines. 17. Capstan haul-off. 18. Transport gantry. 19. Coiling shed. 20. Coiling winch. 21. Loading gantry. 22. Loading caterpillars. 23. Cable ship.

D. Laying From Cable Scows

The use of continuous cable lengths precluded laying shore ends separately and special attention was focused on the problems of getting the ends ashore. Scows or barges with shallow draught and large flat decks are used extensively in the Vancouver area and it was decided to adapt these local craft for laying cables from ship to shore. At the starting and finishing end moorings, around 2,000 ft. of cable had to be transferred to the scow except at the Mainland where a little over 9,000 ft. was needed; the weights involved being approximately 16 and 72 tons respectively. The required cable length was coiled on the scow adjacent to the laying ship. The scow then laid the cable from the ship to the shore. A power winch pulled the free end of the cable up the cable chase to the potheads.

The problems of handling the shore ends of the cables were studied using models and later a full-scale dummy scow and ship were constructed on land. As a result of this work a cable scow was designed with a reversible cable sheave mounted centrally on an A frame structure 25 ft. above the deck. The sheave was powered by a hydraulic variable speed gear also arranged for braking. A compression type cable brake was fitted to the stern so arranged that the cable could be lifted in and out and the brake removed in sections when necessary. A tunnel consisting of wooden ramps with a removable top plate was provided so that the cable could be paid out from under the remaining turns and remove the twist in the cable introduced during coiling. At the stern, a rounded apron was built up so the cable could be pulled off in almost any direction without too sharp a bend. The scow was equipped with winches for warping and cable handling. VHF radio and loud hailers, a compact galley and store below deck, and a navigation platform at the top of the structure completed the equipment.

Final trials were made in England in December 1955 using the "Ocean Layer" and the scow equipment described above mounted on a pontoon of suitable dimensions. The trials proved that the equipment and method was satisfactory and two wooden scows 90 ft. long by 34 ft. wide and about 230 registered tons were fitted out in Vancouver. Their crews were given extensive training prior to the commencement of the actual installation.

Table III Cable Construction

Component	*Radial thickness*	*Cumulative diameter*
Spiral steel duct (internal dia. 0.47 in)	0.030	0.530
Copper conductor 42/.105 in 0.35 in² (445,000 c.m.)	0.210	0.950
Metallized paper conductor screen	0.0105	0.971
Pre-impregnated paper dielectric	0.575	2.121
Copper-tape dielectric screen	0.003	2.129
Alloy E/B.S. 801: 1953) sheath	0.150	2.429
Reinforcement bedding	0.012	2.453
Tinned 1% tin-bronze reinforcing tapes (3 x 0.009 in)	0.027	2.507
Compounded cotton tapes	0.027	2.561
Vulcanized-rubber anti-corrosion sheath	0.120	2.801
Armour bedding	0.118	3.037
Single-wire armour, galvanized steel, 25-32 tons/in² tensile	0.232	3.501
Bituminized cotton tape	0.050	3.601
Jute serving	0.180	3.961

Fault Location and Repair

The location of electrical faults, in general, follows conventional practices. A method was also developed by the cable manufacturers for locating a submerged gas leak. From numerous tests carried out it had been shown that the pneumatic resistance of the cable was very uniform, and accurate formulae were derived relating gas flow to the feed distance. The method developed consists of a loop test using a sound cable, applying a common pressure, and measuring the relative gas flows. By applying the derived formulae the fault position can be calculated.

Means had to be developed for locating and cutting a faulty cable even in the deepest water since it would be impracticable to lift a bight of cable without cutting it. The test methods already referred to, used in conjunction with the record of cables as laid, would give a preliminary location which might be confirmed using Leader gear[5] and by towing a submarine search coil to pick up a signal injected into the faulty cable. Grappling for the cable would then proceed in this area using a specially designed grapnel containing a search coil (to confirm that the correct cable was in the prong of the grapnel) and an explosive charge to be fired from the surface for cutting it. The gas system previously described would limit ingress of water, and the two ends would be recovered separately for jointing-in the required new length of cable.

Gassing, Testing and Commissioning

The cables were charged with nitrogen to a pressure of approximately 10 lb/in² before they were loaded into the cable ship and were checked on arrival in Vancouver. Immediately after laying and before the terminations were made, the cables were tested at 276 kv. d-c. for 15 min. at atmospheric pressure. After the terminations had been made, the cables were gassed at a rate of 50 lb./in² per hour up to 350 lb./in² for a pneumatic overpressure test. The cables were then retested at 276 kv. d-c. for 15 min., and as soon as the circuit was available, line voltage was applied for a period of approximately 48 hours. The cables were brought down to their working gas pressure of 300 lb/in² and the pneumatic system was set to give the required warnings.

After all the cables had been subjected to these tests, the circuits were switched in on load without incident, and the spare cables were maintained at line voltage.

Conclusion

Since the submarine cable interconnection first went into service on September 25, 1956, it has been in continuous operation except for a few short outages for testing and overhead line maintenance. No operating problems have been experienced, except for some minor gas leaks at the terminal equipment, and some relaying troubles. These were remedied, and the interconnection has functioned satisfactorily and efficiently since. During unexpected outages of some hydro-electric plant on Vancouver Island, the submarine interconnection was also called upon to provide additional peaking power from the Mainland system. Thus the cable link has already accomplished its dual purpose of providing a standby as well as normal power supply for Vancouver Island, and the installation has proved to be a practical and economic engineering proposition.

Acknowledgments

The successful completion of the submarine cable interconnection described in this paper is due to the combined efforts of the B.C. Electric Company Ltd., the B.C. Engineering Company Ltd., the B.I.C.C. group of companies and other manufacturers and contractors involved. Special acknowledgment is given to the work of Mr. R. M. Fairfield, Director, British Insulated Callanders Cables Limited and Mr. D. T. Hollingsworth, Director and General Manager, British Insulated Callanders (Submarine Cables) Limited.

The author acknowledges their help with thanks and also the invaluable part played by oceanographers, surveyors, and by the personnel of the cable ships and other vessels.

Table IV Technical Data of Cable and Typical Performance Characteristics

Conductor area	0.35 in² (445,000 c.m.)
Weight in air	52.3 lb yd
Minimum permissible bending diameter	6 ft.
Minimum permissible coiling eye diameter	10 ft.
Maximum permissible twist	36° per yard
Maximum permissible tensile load	6 tons
Working voltage to ground	80 kv.
Current rating	500 amp.
Losses per 3-phase circuit	119 Kw per 1,000 yd.
Maximum conductor operating temperatures—	
In sea	50°C.
On land	70°C.
Cable spacing—	
Strait of Georgia	500 yd.
Trincomali Channel	250 yd.

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A METHOD OF DETERMINING THE POWER POTENTIAL OF RIVERS WITH MANY RESERVOIRS AND POWER PLANTS

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The power potential of modern hydro-systems is a complex problem and present methods of determining it are not entirely satisfactory.

The method presented in this paper is based on previous work by Don Johnstone and John W. Hackney and considers the total power production of the system as the basis for the computations. In addition to the total power potential of the system, the productions and the installations of the individual plants are also determined.

The paper gives the theoretical basis for the computations and includes an example of the application of the method to a typical hydro-system.

1. Introduction

MOST MODERN hydro-systems have interconnected plants which form an integrated system. The determination of the power and energy potential of such river systems is a complex problem.

The usual method of determining the power and energy potential of a river is to undertake a regulation study based on the available flow records. The standard tools for achieving this are the hydrograph, the mass curve and, in the case of remote storage reservoirs, analytical methods. In the case of interconnected systems the application of these techniques is usually based on the assumption that the flow is regulated for the "centre of gravity", which can be determined by some empirical formula.[1] This approach is generally inadequate for complicated systems such as shown on Fig. 3. On the other hand, if every existing reservoir and plant are considered separately in the regulation study[2] the calculations do not give the best combined output of the system.

Fig. 1

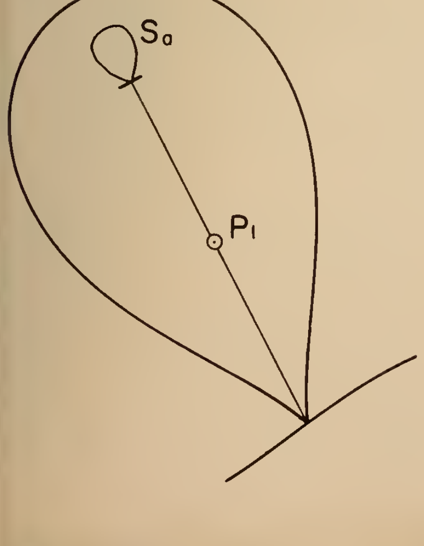
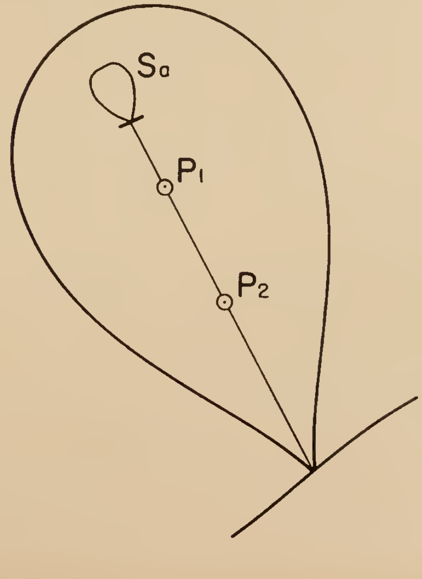


Fig. 2



According to the method described in this paper, the power and energy potential of the river are determined by regulating the total power production of the system instead of the flow at a particular site. The proposed method is a generalization of the concepts introduced by Don Johnstone and John W. Hackney [3,4] and determines the following quantities:

(1) Total power and energy production of the system;

(2) Installations of the individual plants, based on a given prime system load factor.

2. Method of Regulation

2.1 Purpose. The purpose of the regulation study is to use a sufficiently long record of river flows to calculate the power and energy potential of a river system, under the following assumptions:

(1) Throughout the regulation, future run-offs are considered as known;

(2) The operation of the storage reservoirs is determined from the condition that the total power production should be as uniform as possible. This requirement is realistic if the mean monthly loads are approximately constant, or if the storage and pondage capacities are sufficiently large to

equalize the differences between daily and weekly water supply and power demand.

2.2 System with one Plant (Fig. 1). In the simple case of one reservoir and one plant, the average power produced during any month is:

$$k_1 d_a + k_1 f_1 = p \quad ..(1)$$

where

k_1 = kw. c.f.s. ratio for the plant P_1

d_a = discharge from storage S_a in c.f.s.

f_1 = Total uncontrolled run-off at Plant P_1 in c.f.s.

p = Monthly power production in kw.

Equation (1) can be written;

$$d_a + f_1 = (p/k_1) = R \quad ..(2)$$

where R is the regulated flow at the plant P_1. The regulation of the river is achieved by choosing d_a so as to make the regulated flow R (and consequently the power production p) as uniform as possible throughout the period of regulation.

Although for the case of one reservoir and one plant it is more convenient to use equation (2) in the computations, the more direct approach of equation (1) will be used for more complicated cases.

2.3 System with Two Plants (Fig. 2). For a river with two power plants P_1 and P_2, the monthly power production can be expressed as follows:

$$(k_1 + k_2)d_a + k_1 f_1 + k_2 f_2 = p \quad ..(3)$$

where f_1 and f_2 are the *total* uncontrolled run-offs at the plants P_1 and P_2.

Before equation (3) can be used as a bas's for the regulation study, the inflows f_a to the reservoir S_a are multiplied by $(k_1 + k_2)$. The "controlled power" $(k_1 + k_2).\,d_a$ is determined from the condition that the total power p should be as uniform as possible.

2.4 System with any Number of Plants and Storage Reservoirs (Fig. 3). The monthly power production p of the river shown on Fig. 3 can be expressed as follows;

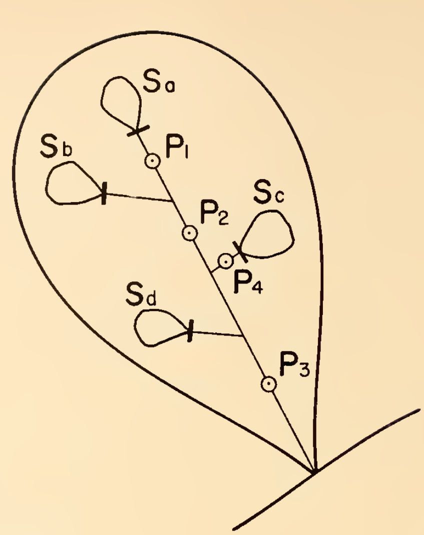


Fig. 3

$$(k_1 + k_2 + k_3)d_a + (k_2 + k_3)d_b + (k_3 + k_4)d_c + k_3 d_d + k_1 f_1 + k_2 f_2 + k_3 f_3 + k_4 f_4 = p \quad ..(4)$$

where

$(k_1 + k_2 + k_3)d_a + (k_2 + k_3)d_b + (k_3 + k_4)d_c + k_3 d_d$ = controlled power

and

$k_1 f_1 + k_2 f_2 + k_3 f_3 + k_4 f_4$ = uncontrolled power

Again, the "controlled power" for any month is determined from the condition that the total power p should be as uniform as possible.

3. Power Production of the Individual Plants

In applying the above method to systems with many reservoirs and plants, the same total power p can be achieved with many combinations of discharges from the individual reservoirs. The actual discharges are determined from the condition that, in addition to the *total* power, the power produced by each individual plant should be as uniform as possible.

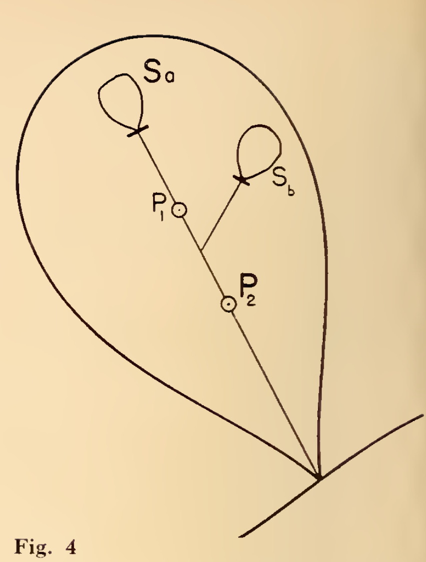


Fig. 4

In the case of the river shown in Fig. 4, we proceed as follows:

Total Power Production

$$p = (k_1 + k_2)d_a + k_2 d_b + k_1 f_1 + k_2 f_2 \quad ..(5)$$

Production of plant P_1

$$p_1 = k_1 d_a + k_1 f_1 \quad ..(6)$$

Production of plant P_2

$$p_2 = k_2 d_a + k_2 d_b + k_2 f_2 \quad ..(7)$$

Power draft from S_a

$$(k_1 + k_2)d_a = \frac{p_1 - k_1 f_1}{k_1}(k_1 + k_2) \quad (8)$$

Power draft from S_b

$$k_2 d_b = p_d - (k_1 + k_2)d_a \quad ..(9)$$

when p_d = total power draft from storages

For a given regulating period we have from equation (6)

$$\Sigma p_1 = \frac{k_1}{k_1 + k_2}\Sigma (k_1 + k_2)d_a + \Sigma k_1 f_1 \quad (10)$$

where

$$\Sigma(k_1 + k_2)d_a = \Sigma(k_1 + k_2)f_a + \Sigma(k_1 + k_2)\Delta S_a$$

and ΔS_a is the change in the storage S_a during the regulating period.

From the total production Σp_1 of plant P_1, we determine the monthly regulated power, taking into account the high values of the uncontrolled power $k_1 f_1$ for some months (usually in the spring).

The necessary additional conditions for the calculation of p_1 are established as follows;

Let p_d = Total power draft

$= p - k_1 f_1 - k_2 f_2$

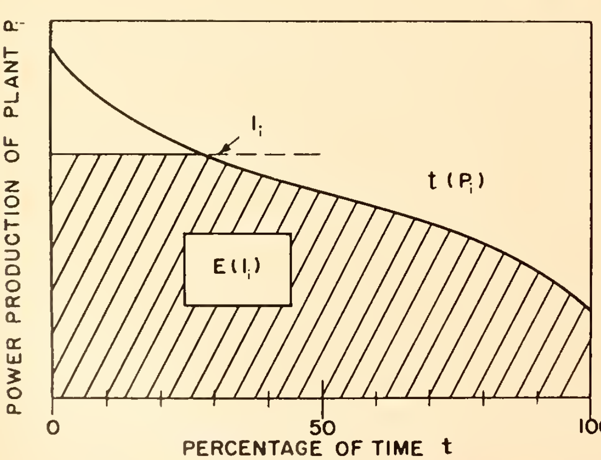
$= (k_1 + k_2)d_a + k_2 d_b.$

We have

$(k_1 + k_2)d_a \le p$ or $d_a \le p_d/(k_1 + k_2)$

and

min. $(p_1) = k_1 f_1 \le p_1$



ENERGY PRODUCTION CORRESPONDING TO INSTALLATION I_i OF PLANT P_i

Fig. 5

$$\leq k_1/(k_1 + k_2).\, P_d$$

$$+ k_1 f_1 = \max.\,(p_1) \quad ..(11)$$

The permissible monthly values of p_1 are also restricted by the storage capacities of the reservoirs S_a and S_b.

The details of the calculation of p_1 and p_2 for each month of the regulating period are carried out as in the usual case of regulation with remote reservoirs. For a full understanding of these calculations the example given at the end of this paper should be studied thoroughly.

This method of determining the power production of individual plants can be applied in the case of systems with many reservoirs and plants, provided that the plants can be considered in groups, the total number of which is equal to the number of storages in the system.

4. Installations of the Individual Plants

The calculation of the total installation, and the installations of the individual plants is based on the duration curves of p and p_1, p_2 . . .

4.1 Total Installation. From the duration curves of p we find the total primary power p_{90} corresponding to a suitable percentage of time (usually about 85 to 90 per cent). Assuming a prime load factor L for the system, we calculate the total installation from the formula:

$$I = p_{90}/L \quad ..(12)$$

4.2 Installations of individual Plants. The installed capacities of the individual plants can be determined from the following conditions:

(1) The sum of the installed capacities should be equal to the total installation

$$I_1 + I_2 + \ldots + I_n = I$$

(2) The sum of the energies produced by the individual plants should be maximum. This criterium can be stated in a more general way as follows:

The installations $I_1, I_2, \ldots$ should be such that the sum

$$F(I_1) + F(I_2) + \ldots + F(I_n)$$

is maximized where $F(I_i)$ is a suitable function of I_i, usually related to the economic losses corresponding to the installation I_i.

The second condition, in its simpler form, can be applied as follows for the calculation of the installations[5];

The energy produced by the Plant P_i (Fig. 5) with an installation I_i is:

$$E(I_i) = \int_0^{I_i} t(p_i)dp_i \quad (13)$$

where $t(p_i)$ = percentage of time corresponding to the power p_i.

The above conditions can now be expressed as follows:

(1) $I_1 + \ldots + I_n = I$

$E_1(I_1) + \ldots + E_n(I_n) = E$

(2) should be maximum

The condition for maximizing E is:

$$dE = \frac{dE_i}{dI_i}dI_1 + \ldots + \frac{dE_n}{dI_n}dI_n = 0 \quad (14)$$

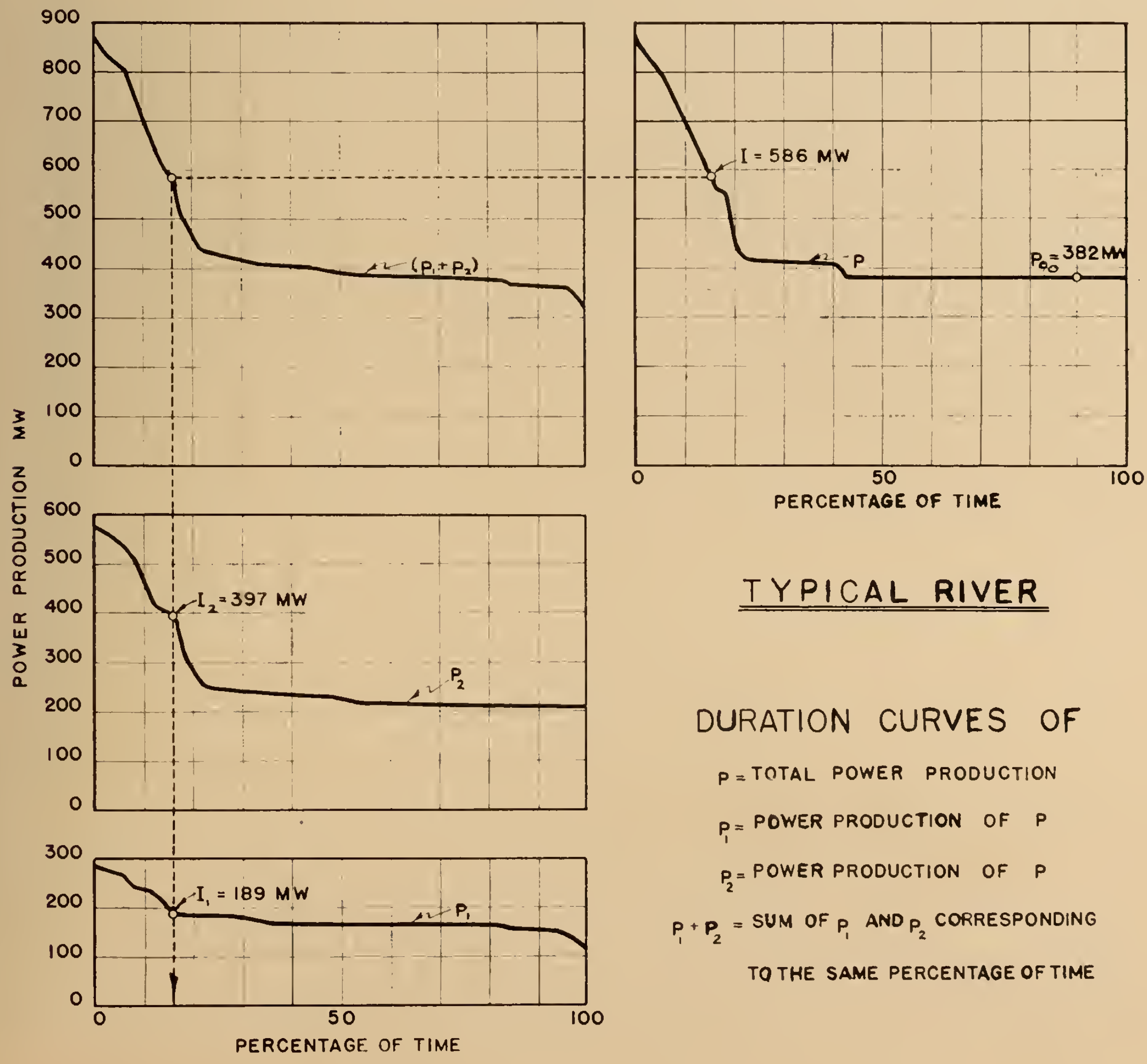
From condition (1) we have

$$dI_1 = -dI_2 - \ldots - dI_n.$$

Substituting in (14) we find:

$$dE = \frac{dE_1}{dI_1}(-dI_2 - \ldots - dI_n)$$

Fig. 6



$$+\frac{dE_2}{dI_2}\cdot dI_2 + \ldots + \frac{dE_n}{dI_n}\cdot dI_n$$

$$dE = \left(\frac{dE_2}{dI_2} - \frac{dE_1}{dI_1}\right) dI_2 + \ldots + \left(\frac{dE_n}{dI_n} - \frac{dE_1}{dI_1}\right) dI_n = 0 \qquad (15)$$

and because the differentials $dI_2, \ldots dI_n$ are now independent, we must have

$$\frac{dE_1}{dI_1} = \frac{dE_2}{dI_2} = \ldots = \frac{dE_n}{dI_n} \qquad (16)$$

But, from (13) we have:

$$\frac{dE_i}{dI_i} = t(I_i)$$

and therefore, the condition for maximizing E is:

$$t_1(I_1) = t_2(I_2) = \ldots = t_n(I_n) \qquad (17)$$

Equations (17), together with the equation

$$I_1 + \ldots + I_n = I$$

determine the installations $I_1, \ldots I_n$.

The calculations are carried out in the following way:

From the duration curves of $p_1, \ldots p_n$, we determine the curve of $(p_1 + \ldots + p_n)$ by adding together the p's corresponding to the same percentage of time (Fig. 6). From this curve, we read the percentage of time corresponding to the total installation I.

The installations of all plants correspond to this percentage of time and are found from the duration curves of $P_1 \ldots P_n$ as shown on Fig. 6.

Of course, before a final decision is made concerning the individual installations, consideration must be made of certain practical problems such as the consistency of installation in series of plants, necessary for the efficient use of the water during the time when water is being withdrawn from storage.

5. Example of the Application of the Method

5.1 Basic data for the typical river. The watershed of the typical river is shown in Fig. 4.

Heads

Head of plant P_1 = 805 ft.
Head of plant P_2 = 535 ft.

Total Head 1340 ft.

At 88% efficiency we have;

$k_1 = 0.0746 \times 805 = 60$ kw./c.f.s.
$k_2 = 0.0746 \times 535 = 40$ kw./c.f.s.

$(k_1 + k_2) = 100$ kw./c.f.s.

Storage Capacities

S_a = 11,000 c.f.s.-months
= 11,000 × 100 = 1,100 Mw.-mos
S_b = 7,500 c.f.s.-months
= 7,500 × 40 = 300 Mw.-mos

Flows

The inflows of the reservoirs, f_a and f_b, and the total uncontrolled run-offs at the plants (f_1 and f_2) are given in the regulation tabulation (Table 1).

5.2 Regulation Study. The total regulated power p is determined as in the usual type of regulation study. The drafts from the reservoirs S_a and S_b are calculated from the condition that, in addition to the total power production p, the production of each individual plant should be as uniform as possible. The details of the regulation study are shown in the regulation tabulation.

5.3 Installations of the Plants. After the completion of the regulation study we plot the duration curve of the total power production p (Table 2 and Fig. 6). From this curve we find that the power available 90 per cent of the time is p_{90} = 382 Mw. Assuming a load factor of 65 per cent, the total installation I = 382/0.65 = 586 Mw. From the duration curves of the individual power productions p_1 and p_2 we construct the curve of $(p_1 + p_2)$ as described in the text. From this curve we find that the total installation of 586 Mw. corresponds to 16.32 per cent of the time, and therefore the installations of plants p_1 and p_2 are 189 Mw. and 397 Mw. respectively.

The total energy spill (area under the curve $p_1 + p_2$ above 586 Mw.) is

$$\frac{(844+586)}{48} - 0.1632 \times 585 = 24.36$$

Mw. years.

or 24.36 × 8760 × 1000 = 0.213 billion kwh.

5.4 Power and energy potential of the typical river.

Total primary energy

382,000 × 8760 = 3.35 billion kwh.

Total energy under the duration curve of p:

21,547/48 × 8,760 = 3.93 billion kwh.

Secondary energy:

3.930 − 3.350 − 0.213 = 0.367 billion kwh.

Total installation .... 586 Mw.
Installation of Plant P_1....... 189 Mw.
Installation of Plant P_2....... 397 Mw.

5.5 Remarks on the Computations. The first step of the study is the computation of the power inflows to the reservoirs and the power plants. The repetitive nature of this computation justifies the use of punched-card computing machines, especially in the case of long flow records. After the power inflow columns are filled in the tabulation, the regulation study can be easily carried out with a desk calculator. The resulting total and individual regulated powers are then arranged in order of magnitude, using punched-card sorting machines. In this way, the time devoted to the regulation study by competent office personnel is kept to a minimum. In general the time spent in the engineering office for the completion of a study of total power production is not appreciably longer than required for a regulation study restricted to one power plant.

DURATION TABULATIONS

p	p_1	p_2	p_1+p_2	%
844	278	566	844	2.04
814	270	544	814	4.08
779	264	542	806	6.12
731	238	515	753	8.16
696	233	463	696	10.20
643	230	413	643	12.24
618	211	407	618	14.28
557	189	397	586	16.32
553	183	319	502	18.36
430	183	278	461	20.40
419	183	251	434	22.44
419	183	247	430	24.48
419	183	245	428	26.52
419	183	239	422	28.56
419	180	239	419	30.60
419	179	236	415	32.64
418	173	236	409	34.68
418	169	236	405	36.72
418	169	236	405	38.76
418	169	236	405	40.80
382	169	235	404	42.84
382	169	234	403	44.88
382	169	231	400	46.92
382	169	229	398	48.96
382	169	228	397	51.00
382	169	221	390	53.04
382	169	217	386	55.08
382	169	217	386	57.12
382	169	215	384	59.16
382	169	214	383	61.20
382	169	214	383	63.24
382	169	213	382	65.28
382	169	213	382	67.32
382	169	213	382	69.36
382	168	213	381	71.40
382	168	213	381	73.44
382	167	213	380	75.48
382	167	213	380	77.52
382	165	213	378	79.56
382	165	213	378	81.60
382	161	213	374	83.64
382	156	213	369	85.68
382	154	213	367	87.72
382	153	213	366	89.76
382	152	213	365	91.80
382	151	213	364	93.84
382	148	213	361	95.88
382	135	213	348	97.92

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NOTE: Discussion on this paper will be published in the November issue of *The Engineering Journal*.

REGULATION COMPUTATIONS FOR TYPICAL RIVER

TABLE 1

YEAR		OPERATION OF RESERVOIR S_a CAPACITY = 1,100 Mw.-Mos.				OPERATION OF RESERVOIR S_b CAPACITY = 300 Mw.-Mos.				OPERATION OF PLANT P_1						OPERATION OF PLANT P_2			SYSTEM OPERATION					
	Month	Inflow c.f.s. Mos.	Power Inflow Mw.-Mos.	Power Draft Mw.-Mos.	Power Left Mw.-Mos.	Inflow c.f.s. Mos.	Power Inflow Mw.-Mos.	Power Draft Mw.-Mos.	Power Left Mw.-Mos.	Uncontrolled Run-off c.f.s. Mos.	Uncontrolled Power k_1f_1 Mw.-Mos.	$\frac{k_1}{k_1-k_2}Pd$ Mw.-Mos.	Maximum P_1 Mw.-Mos.	P_1 Mw.-Mos.	$P_1-k_1f_1$ Mw.-Mos.	Uncontrolled Run-off c.f.s.-Mos.	Uncontrolled Power Mw.-Mos.	P_2 Mw.-Mos.	Total Power Inflow Mw.-Mos.	Uncontrolled Power Inflow Mw.-Mos.	Controlled Power Inflow Mw.-Mos.	Total Pd from Storage Mw.-Mos.	Total Power Left in Storage Mw.-Mos.	Total Regulated Power Mw.-Mos.
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1950	M	4,350	435	0	435	2,100	84	0	84	4,400	264			264	0	12,480	515	515	1,298	779	519	0	519	779
	J	4,120	412	0	847	2,050	82	0	166	4,500	270			270	0	13,520	544	544	1,308	814	494	0	1,013	814
	J	3,070	307	54	1,100	1,600	64	0	230	2,980	179			211	32	9,650	385	407	935	564	371	54	1,330	618
	A	1,870	187	187	1,100	960	38	0	268	2,100	126			238	112	6,100	244	319	595	370	225	187	1,368	557
	S	720	72	235	937	350	14	56	226	700	42	175	217	183	141	2,160	86	236	214	128	86	291	1,163	419
	O	1,070	107	195	849	400	16	25	217	1,100	66	132	198	183	117	3,340	133	236	322	199	123	220	1,066	419
	N	1,140	114	185	778	500	22	22	217	1,200	72	124	196	183	111	3,500	140	236	348	212	136	207	995	419
	D	1,550	155	140	793	650	26	0	243	1,600	96	84	180	180	84	4,580	183	239	460	279	181	140	1,036	419
1951	J	760	76	230	639	380	15	57	201	750	45	172	217	183	138	2,180	87	236	223	132	91	287	840	419
	F	550	55	245	449	280	11	74	138	600	36	191	227	183	147	1,600	64	236	166	100	66	319	587	419
	M	440	44	250	243	210	8	86	60	550	33	202	235	183	150	1,230	49	235	134	82	52	336	303	418
	A	1,700	170	124	289	850	34	0	94	1,650	99	74	173	173	74	4,870	195	245	498	294	204	124	383	418
	M	3,760	376	0	665	1,500	60	0	154	3,880	233	0	233	233	0	11,550	463	463	1,132	696	436	0	819	696
	J	2,840	284	0	949	1,600	64	0	218	2,530	152	0	152	152	0	6,950	278	278	778	430	348	0	1,167	430
	J	1,750	175	118	1,006	1,150	46	0	264	1,800	108	71	179	179	71	4,800	192	239	521	300	221	118	1,270	418
	A	1,820	182	88	1,100	910	36	0	300	1,900	114	53	167	167	53	5,400	216	251	548	330	218	88	1,400	418
	S	840	84	185	999	350	14	38	276	950	57	134	191	168	111	2,540	102	214	257	159	98	223	1,275	382
	O	1 220	122	148	973	650	26	12	290	1,300	78	96	174	167	89	3,600	144	215	370	222	148	160	1,263	382
	N	1,160	116	162	927	550	22	13	299	1,150	68	105	173	165	97	3,480	139	217	345	207	138	175	1,226	382
	D	920	92	191	828	440	18	30	287	880	53	133	186	168	115	2,700	108	214	271	161	110	221	1,115	382
1952	J	530	53	216	665	210	8	64	231	650	39	168	207	169	130	1,580	63	213	163	102	61	280	896	382
	F	440	44	238	471	200	8	62	177	430	26	180	206	169	143	1,400	56	213	134	82	52	300	648	382
	M	350	35	243	263	180	7	73	111	380	23	190	213	169	146	1,080	43	213	108	66	42	316	374	382
	A	460	46	238	71	250	10	70	51	430	26	185	211	169	143	1,210	48	213	130	74	56	308	122	382
	M	4,240	424	0	495	1,150	46	0	97	4,630	278	0	278	278	0	14,180	566	566	1,314	844	470	0	592	844
	J	3,320	332	0	827	1,580	63	0	160	3,150	189	0	189	189	0	13,560	542	542	1,126	731	395	0	987	731
	J	1,660	166	88	905	830	33	1	192	1,800	108	53	161	161	53	4,620	185	221	492	293	199	89	1,097	382
	A	1,500	150	120	935	780	31	0	223	1,320	79	72	151	151	72	4,580	183	231	443	262	181	120	1,158	382
	S	1.200	120	168	887	650	26	2	247	1,130	68	102	170	169	101	3,600	144	213	358	212	146	170	1,134	382
	O	2,060	206	12	1,081	1,100	44	5	286	2,130	128	10	138	135	7	5,920	237	247	615	365	250	17	1,367	382
	N	860	86	205	962	450	18	25	279	770	46	138	184	169	123	2,630	106	213	256	152	104	230	1,241	382
	D	570	57	218	801	280	11	54	236	630	38	163	201	169	131	1,800	72	213	178	110	68	272	1,037	382
1953	J	440	44	236	609	250	10	64	182	450	27	180	207	169	142	1,370	55	213	136	82	54	300	791	382
	F	410	41	243	407	200	8	62	128	380	23	183	206	169	146	1,340	54	213	126	77	49	305	535	382
	M	380	38	250	195	180	7	73	62	310	19	194	213	169	150	990	40	213	104	59	45	323	257	382
	A	1,590	159	98	256	850	34	0	96	1,480	89	59	148	148	59	4,880	195	234	477	284	193	98	352	382
	M	3,720	372	0	628	1,800	72	0	168	3,830	230	0	230	230	0	10,300	413	413	1,087	643	444	0	796	643
	J	2,780	278	0	906	1,480	59	0	227	2,600	156	0	156	156	0	9,920	397	397	890	553	337	0	1,133	553
	J	1 720	172	73	1,005	900	36	1	262	1,810	109	44	153	153	44	4,970	199	229	516	308	208	74	1,267	382
	A	740	74	210	869	320	13	36	239	710	43	148	191	169	126	2,320	93	312	223	136	87	246	1,108	382
	S	1,670	167	103	933	950	38	0	277	1,530	92	62	154	154	62	4,680	187	228	484	279	205	103	1,210	382
	O	1,230	123	147	909	620	25	10	292	1,280	77	94	171	165	88	3,700	148	217	373	225	148	157	1,201	383
	N	930	93	188	814	480	19	23	288	980	59	127	186	169	110	2,800	112	213	283	171	112	211	1,102	382
	D	910	91	190	715	460	18	53	253	910	55	146	201	169	114	2,100	84	213	248	139	109	243	968	382
1954	J	570	57	220	552	290	12	61	204	610	37	169	206	169	132	1,600	64	213	170	101	69	281	756	382
	F	440	44	230	366	220	9	77	136	510	31	184	215	169	138	1,100	44	213	128	75	53	307	502	382
	M	420	42	213	195	210	8	87	57	680	41	180	221	169	128	1,030	41	213	132	82	50	300	252	382
	A	530	53	218	0	280	11	68	0	330	20	190	210	169	149	1,150	46	213	130	66	64	316	0	382
TOTALS			7,132				1,384				4,347						8,684		21,547					21,547

SILVER FALLS GENERATING STATION

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C. T. Bath, **B.E., P.Eng., A.M.I.E.** (Aust.) *Construction Project Engineer The Hydro Electric Power Commission of Ontario*

The tunnel at Silver Falls is two miles long and was driven to 17 ft. 6 in. diameter; it will later be lined with 18 in. of concrete to a diameter of 14 ft. 6 in. Rock at the site was granite and paragneiss—generally fairly competent.

The equipment was all set up for a tracked operation, i.e., a one cu. yd. bucket capacity electric mucking machine, a number of 6 cu. yd. mine cars, a 7 drill main line jumbo, one 15-ton and two 10-ton locomotives.

An interesting feature of the tunnel driving was the construction of the two ancillary shafts, i.e., the 300 ft. intake shaft and the 200 ft. surge shaft. These shafts were excavated in three steps by a method believed to be new to Canada:

1) A pilot hole was driven from the surface to the tunnel;

2) A hoist was set up on the surface and used to support a cage for two men to drill a 6 ft. diameter pilot raise;

3) The shaft was slashed down to full size.

THE DEVELOPMENT of the Silver Falls site, where there is a difference of head of some 360 ft. between Dog Lake and Little Dog Lake, has long been considered attractive, and it became economically justified as a peak load plant following the development of all but one of the remaining hydraulic generating sites in Northwestern Ontario.

The general topography of the area, river flow records and an extensive geological survey established that the development would consist of an intake structure and shaft located on the south shore of Dog Lake and a single unit 62,000 hp. generating station at the upper end of Little Dog Lake, connected by a concrete lined 14 ft. 6 in. diam. hydraulic tunnel almost two miles long. In addition, there would be a surge shaft and tank located 900 ft. upstream of the powerhouse.

Concurrently with the preparation of engineering preliminary plans, estimates and field surveys, the construction planners developed their schedules and methods of operation. The tunnel would be driven with 3 ft. gauge track equipment from the penstock portal which was to be serviced by a track cut located outside the powerhouse excavation. Following Commission authorization to proceed on February 13, 1957, initial orders for materials and equipment were placed and field operations commenced early in April, 1957.

During the ensuing 6 months, 20 miles of road were built or regraded, 45 acres of shop and camp facilities were laid out and erected, and sufficient overburden and rock was removed to commence tunnelling operations from the penstock portal on October 8, 1957.

The geological survey, which included seismological and diamond drill investigations, indicated reasonably competent paragneiss and granite rock over the length of the tunnel and shafts, with the possible exception of a rock depression 1500 ft. from the intake.

The 3 ft. gauge track equipment used for driving the tunnel consisted of a main line 7 drill jumbo mounted on bogies, an electrically driven 1 cu. yd. mucking machine equipped with a loading conveyor, two 10 and one 15-ton diesel locomotives, and an assortment of used 5 and 6 cu. yd. ore cars, flat cars, dynamite and vent pipe handling cars.

The drill jumbo, which proved highly successful, was equipped with the latest type of hydraulic boom mounted screw feed drifter drills with 8 ft. aluminum shells. Both decks were equipped with three 3½ in. piston machines using 1¼ in. round lugged steel, the lower machines being underslung with offset booms. An additional 4½ in. machine mounted on a tripod boom and centrally located between decks was used for drilling the burn cut and square-up holes. The upper deck was provided with hydraulically actuated flaps, which when raised formed a platform 16 in. wide and 36 ft. long.

The jumbo was equipped with 6 in. and 4 in. air, water and drainage headers which were coupled directly into the tunnel service pipes by bull-hoses, the latter discharging drainage water from a vacuum pump located on the lower deck.

The hydraulic system was powered by two air motors, and the main's water pressure was boosted to 80 p.s.i. by a duplex air pump. Dynamite was handled to the upper deck by an elevator driven by a tugger hoist. Spare parts, including three complete drills together with oxy-acetylene burning equipment, were carried in purpose-made brackets on the jumbo.

The tunnel was excavated to a nominal bore of 17 ft. 6 in. diameter modified to a horseshoe shape to facilitate subsequent concrete lining operations.

The burn cut drilling pattern which was adopted consisted of two 4 in. or 3½ in. diameter cut holes with a blast hole in between them, a sweeper hole and six cut square-up holes, all 2½ in. diameter, and drilled off with the 4½ in. machine using 1¼ in. hexagon sectional "carborized" steel and series 600 tungsten carbide insert bits. The remaining holes, including the perimeter holes which were spaced 2 ft. 6 in. apart, were drilled off in blocks of ten by the six 3½ in. machines using 1¼ in. diameter round lugged carbon steel with detachable tungsten carbide insert 1⅞ in. and 2 in. D thread bits.

Average powder factors were:

5.1 lbs/cu.yd. for tunnel
8 lbs/cu. yd. for shaft pilot raises

and
2.5 lbs/cu.yd. for slashing down.

Each shift comprised a crew of 28 as follows:

Shift boss
Walking Boss
Jumbo Leader
9 miners 7} on jumbo
6 helpers 5}
2 motormen
2 switchmen
1 electrician
1 pipefitter
1 mucking machine operator
1 dumpman
1 drill mechanic
1 oiler

On day shift only, there were 6 additional personnel as follows:
1 track foreman
2 trackmen
1 labourer
1 powderman
1 pumpman

The tunnel alignment and grade was maintained by an offset centre line and concrete monuments, each face being marked up by an instrument man and chain man with a transit and radius chain.

Blasting was done electrically by a 220-v. circuit using 8 in. sticks of 1¼ in. diameter 70% driftite and 0 to 14 long period X-107A detonators with 20 ft. lead wires.

Each shift was supplied with up to 30 lengths of 8 ft. and 16 ft. and 8 lengths of 18 ft. round lugged steel with 2 in. and 1⅞ in. bits attached, together with 10 lengths of sectional steel with couplings, 2½ in., 3½ in. and 4 in. bits partly assembled.

At the outset and until January 3, 1958, first 12 ft. and then 14 ft. rounds were drilled off until the crews became fully conversant with the equipment and maintained the required cycle of a round per shift.

A bit testing programme established the make of bits with the best performance for the type of rock encountered. Including test bits, the overall footage obtained was 299 for the D series bits and 296 and 451 for the 4 in. and 2½ in. 600 series bits respectively. The bit life was considerably increased when the operation at the face became stabilized at 46 ft. per day and the steel shop techniques were improved and under better control. Thus for the latter two-thirds of the tunnel the bit life was 398 and 374 ft. respectively for the 2 in. and 1⅞ in. bits.

Likewise, the steel life figures showed a similar improvement, the 8 ft. increasing from 245 to 818 and the 16 ft. from 371 to 540.

The tunnelling crews received production bonus for average daily advances in excess of 28 ft. a day and although there were many occasions when the men would have preferred to break cycle and gain extra rounds, they were restrained from doing so in the interests of safety. The accident record of no fatalities and no serious injuries producing permanent disability justified this policy.

The average times spent on the various operations for each shift were as follows:

Drilling	2 hr. 30 min.
Loading and blasting	1 hr.
Exhaust smoke and lunch break	30 min.
Mucking, scaling and cleanup	3 hr.
Laying track, installing pipe, setting up jumbo and travelling time	1 hr.

The job operated on a 6-day, three 8 hr. shift basis with a scaling shift on the seventh day. The average rate of advance over the whole length was 40.5 ft. per day, but for the last seven months when 16 ft. steel was used the average was approximately 45 ft. per day.

Primers for all three shifts were prepared in advance by the dayshift powderman and delivered to the tunnel in compartmented containers as required.

Blasting was done electrically on a 200 v. circuit. The charge at the face was divided horizontally into two series, and by using a four-conductor cable for the last 300 ft. the two series were kept isolated until a disconnecting plug and socket 300 ft. from the face was closed. In this way induced voltages in the blasting leads could not cause circulating currents while the crew was in the vicinity of the face. The blasting cable, which was located along the spring line on the opposite side of the tunnel to the power cables, transformer stations and lighting circuits, ran from this point to the blasting stations locked switch. This was for the most part outside the portal, but was later moved inside the tunnel when tests proved the noise frequency level to be tolerable. The crew wore ear muffs when using the blasting station inside the tunnel. Loading was abandoned when lightning storms were imminent.

Immediately following the blast, the mucking machine was moved up to the face by the first muck train and proceeded to clean up the scattered rock whilst the smoke cleared.

We were fortunate in obtaining permission to dispose of 100,000 cu. yd. of tunnel rock in a nearby bay on Little Dog Lake, which kept the track grades down to 2% or less. This allowed us to haul up to twelve and eight loaded cars behind the 15 and 10 ton locomotives respectively. Some of the rock from the dump was crushed, screened, and washed to provide most of the coarse aggregate required for the project's 60,000 cu. yd. of concrete. The triple roll apron-fed portable crusher, which produced 1,000 tons a day, was equipped with an electro magnet for removing tramp iron.

The underground haulage system included four passing tracks 200 ft. long arranged in pairs at the third points along the tunnel, the first one of each pair being equippel as a servicing bay for the jumbo and mucking machine. The tunnel section was enlarged at the passing tracks, which, together with the transfer switch and transformer pocket slashes at 275 and 1100 ft. intervals respectively, were made on the fly without affecting progress at the face.

The ventilation system, which provided 15,000 c.f.m. of air on exhaust and 10,000 c.f.m. on blow, consisted of a 24 in. diameter spiral weld pipe in 40 ft. lengths, with banks of 4 contra-rotating axial flow fans at 2,200 ft. intervals. It proved very effective in that daily testing for noxious gases from diesel and dynamite fumes never showed a higher concentration than the limits specified by the Department of Labour. The pipes were transported and lifted into position on two flat cars equipped with cradled arms actuated by hand-operated hydraulic rams. They were suspended from the tunnel arch by ¼ in. diameter cable attached to two 18 in. eye bolts with expansion shells.

Power was supplied to the site at 13.2 kv. from Kakabeka D.S. A transformer station set up 700 ft. outside the portal transformed the 13.2 kv. star system to a 2.3 kv. delta system. A higher voltage than 2300 would have presented insulation problems, while at a lower voltage regulation would have exceeded acceptable values unless a large cable were used.

Power requirements were as follows:

a) *Ventilation* — Groups of four fans each 25 h.p. were set in the ventilation pipe at 2,200 ft. intervals. A bank of three 25 kva. transformers was used for each group.

b) *Mucking Machine* — Two motors had a total capacity of 130 h.p. Three 37½ kva. transformers were used. One 37½ kva. transformer was kept as a spare.

c) *Lighting* — 3 watts per ft.

d) *Electric Drainage Pumps* — 1½ in. and 3 in. had capacities of 1½ and 3 h.p.

All cables in the tunnel had to satisfy Mining Regulations. The main distribution cable was an armoured No. 2/0 size cable, rubber insulated, neoprene jacketed rated at 4 kv. The cable came in lengths of 1,100 ft., i.e., between transformer stations. Pockets for the transformer stations were slashed out during the tunnel driving so that all equipment could be set safely back from the rail tracks. Tunnel transformers were filled with non-inflammable liquid and had 4¼% taps for compensating voltage regulation.

Since no permanent equipment could be installed within 300 ft. of the face, a trailing cable 1,450 ft. long was required to cover the 1,100 ft. between transformer pockets plus this 300 ft. to supply power to the face. This cable was *type G*, neoprene jacketed for rough usage and rated at 1000 v. Voltage was transformed down to 550 v. at the input end of this line.

For lighting supply to the face a single phase 600-120/240 v., 5 kva. mobile transformer was kept 300 ft. back from the face. This was connected back to the 37½ kva. transformer by 1,100 ft. of *type W* neoprene jacketed No. 14 cable also wound on a reel.

For permanent lighting a 5 kva., 2400-120/240 v. transformer was installed every 1,100 ft. Each transformer supplied lighting 550 ft. behind and ahead of its position. Pin type sockets were used for the lifts in preference to pig tail sockets. The main current path was a two conductor, No. 2 PVC 600 v. cable surplus from other jobs and with the lamps being attached to shorter lengths of one conductor No. 12 PVC 600 v. cable spliced into the main cable.

During the winter, a 1,250,000 B.T.U. hot air oil-fired furnace, which was piped directly into the ventilating system, raised 10,000 c.f.m. of air 70°. This prevented a build-up of ice at the portal and considerably improved working conditions in the tunnel.

The compressed air supply from the central boiler and compressor house, which had an installed capacity of 3,300 c.f.m., was piped to the face through 12 gauge 6 in. diameter spiral weld pipe. The water supply and drainage system were conveyed in 14 gauge 4 in. and 6 in. diameter pipes. All three pipes were in 40 ft. lengths connected together by cast iron couplings with rubber seals, and carried along the left hand tunnel wall on purpose made triple rack pipe hangers.

Drainage water was pumped into the main line by 1½ in. diameter, 220 v. submersible pumps and four sludge tanks equipped with automatic 3 in. diameter 550 v. submersible pumps were located at 1,000 ft. intervals behind the face.

A blacksmith's shop was set up for threading, lugging and rehabilitating the 1¼ in. round carbon steel. This allowed us to make immediate changes in the length of our steel, ensured adequate supplies with a minimum stock in reserve and dispensed with heavy transportation costs to and from the suppliers in Eastern Canada. Final costs show that, including the write-off of shop equipment, steel costs were less than those for buying steel ready made: steel life was equal to or better than that of manufactured steel used in the initial stages. The four wing bits were removed from the steel, checked for gauge loss and insert failure, and then sharpened with a semi-automatic grinder or replaced as required.

In addition, the blacksmiths produced thousands of bull horn pins, pipe and cable hangers, track gauge spacers, scaling bars and mining gads.

The two shafts, namely a 200 ft. surge shaft and a 300 ft. intake shaft, were excavated by a relatively new method which was developed in Sweden.

A pilot or cable hole was first drilled from the surface to the tunnel. In the case of the surge shaft a churn drill was used to drill a 9 in. diameter hole. The rate of progress was slow and it wandered about 5 ft. off plumb. Most of this deviation however was in the last 20 ft. so that by the time several rounds were taken out the hole was near enough to vertical to allow the cage to be used in the next step. A 4 in. diamond drill hole was used for the intake shaft. It remained within 1 ft. of the vertical alignment and was drilled in a third of the time.

However, during the raising of the shafts it was found that there were two serious disadvantages in the 4 in. hole. Firstly, several rounds froze due to its inadequacy as a burn cut whilst preventing us from using a draw or vee cut, and secondly blowing smoke took five times as long.

A 5 ft. diameter steel cage was suspended on a wire rope passing through the hole from a geared down 75 h.p. electric mine hoist on the surface. Two men used the cage as a platform to drill and load each 8 ft. round of the 6 ft. diameter pilot raise, after which it was lowered to the bottom of the raise and stowed away for each blast.

The cage was hoisted to the face after the smoke had cleared, any loose rock being scaled down. It was then wedged against the sides of the raise by three spuds and six telescopic arms at the sides and the top of the cage respectively, the latter being used to support a moveable wooden drill platform.

Services — air, water communication lines, were paid out from below. After the pilot raise was completed, the shaft was slashed down to the finished 17 ft. 6 in. diameter in 10 ft. rounds from the surface by a 10 man crew using 6 jackhammers.

A second cage 5 ft. square with drawbridge style sides was used in its closed position for hoisting the men and materials, plugging the raise during drilling and loading, and in its open position for scaling and guniting.

Since the surge shaft was excavated concurrently with the tunnel, it was mucked out through a loading hopper and chute, whereas the intake shaft, which was started after the tunnel driving had been completed, was mucked out from the tunnel floor.

This method proved to be considerably safer and faster than conventional methods, and further application of the equipment would of course make the method even more desirable.

The rock in both the tunnel and shafts proved to be generally very good with little water seepage. Steel arch ribs were on the site to meet any emergency, but were never used. 2,000 Roof bolts up to 10 ft. long were required in the latter stages, especially under the rock depression previously mentioned.

Overlapping exploratory diamond drill holes were carried ahead of the face to antipicate adverse rock or

(Continued on page 122)

THE DESIGN OF A DANIELS-BOYD NUCLEAR STEAM GENERATOR A 400 MW. (NET E) POWER PLANT

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A full description of the Canadian nuclear steam generator, suitable for use in a public utility power station and incorporating an active circuit, helium cooled, ceramic reactor of the general type first proposed by Dr. Farrington Daniels.

THE DANIELS-BOYD Nuclear Steam Generator (see Fig. 1) is a device which utilized the heat from uranium fission to produce high quality steam (2,400 psiG, 1,050°F.) for the generation of electricity in large public utility power stations. It has two major advantages over the other nuclear steam generators at present in operation or under construction. These are:

(a) The power output has been greatly increased in spite of reduction in size and/or complexity;

(b) The overall thermodynamic efficiency in the conversion of heat to electricity has been increased to 33½%.

Both these advantages stem from the high reactor core temperatures which have been made possible by eliminating from the core non-refractory materials such as metals. Because of this and other improvements, a nuclear power station incorporating a Daniels-Boyd Reactor (DBR) in its present form will produce electrical power in Canada at a cost competitive with that from the most modern coal-fired stations. Moreover the development potential of the DBR is such that power costs will decrease significantly as operating experience is gained, since the present design parameters are deliberately conservative.

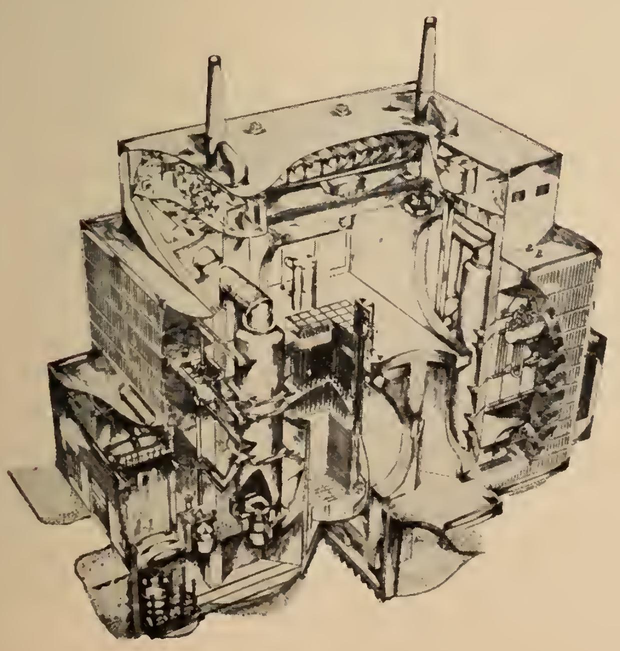


Fig. 1 Daniels-Boyd Nuclear Steam Generator.

Description

Superficially the Daniels-Boyd Nuclear Steam Generator greatly resembles the equivalent devices found in the English nuclear power stations now under construction, particularly those at Bradwell, Hunterston and Hinkley Point. In both designs the heat producing reactor core is contained in a steel sphere about 70 ft. in diameter filled with the primary cooling gas under pressure (200 psiA for Hinkley Point and 215 psiA for the DBR). In both also this so-called cooling gas (CO_2 for the English reactors, helium for the DBR) is circulated through the reactors and the heat exchangers or steam raising units where water is boiled and the resulting steam is superheated. The superheated steam is then used to drive conventional steam turbines coupled to generators. However, due to the low operating temperatures of the English reactors, the steam turbines associated with them are low temperature and pressure affairs and cannot therefore be built in the very large sizes required for modern public utility power stations. By comparison the most modern type of turbo-generator can be used in a power station incorporating a D-B Nuclear Steam Generator and we have, in fact, obtained a preliminary quotation on a suitable 450 Mw. unit.

The D-B Nuclear Steam Generator is based on the use of a mildly active circuit. This resulted from the reasoning that if a reactor is designed for a closed cooling circuit and appropriate scavenging,* then cladding or canning as it was originally called, can logically be eliminated. The canning tradition began with the early plutonium production reactors in which atmospheric air or river water was circulated for cooling. Thus fission products could not be allowed to get into these coolants which were subsequently discharged. Consequently all the fuel elements were canned. This was possible because with the low reactor temperatures which could be used, the cans could be made of relatively cheap metal which was reasonably compatible from the nuclear point of view and at the same time sufficiently corrosion resistant.

*See Addendum.

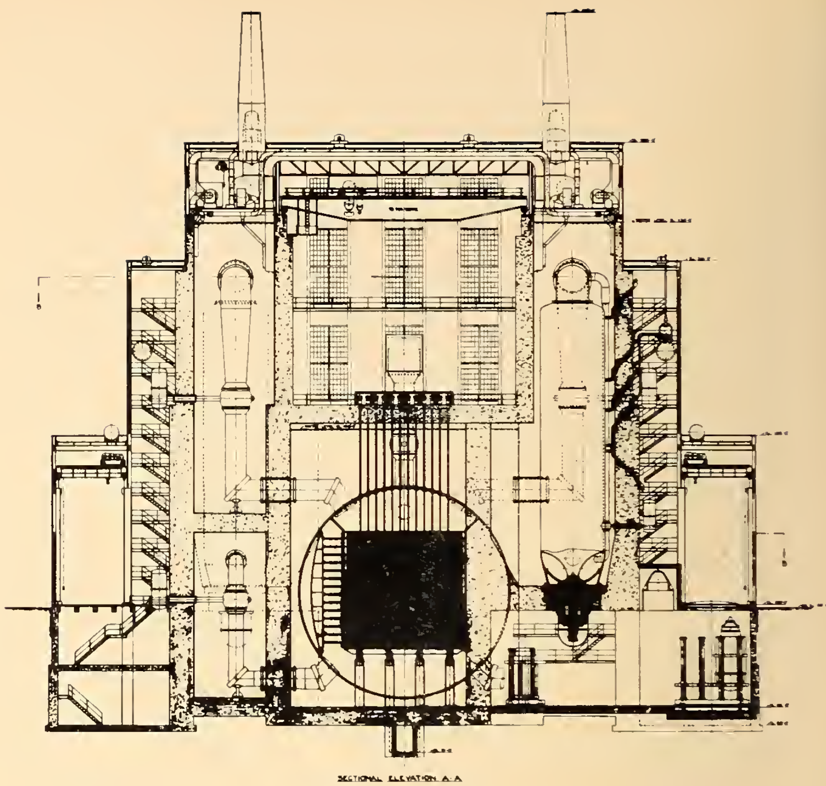
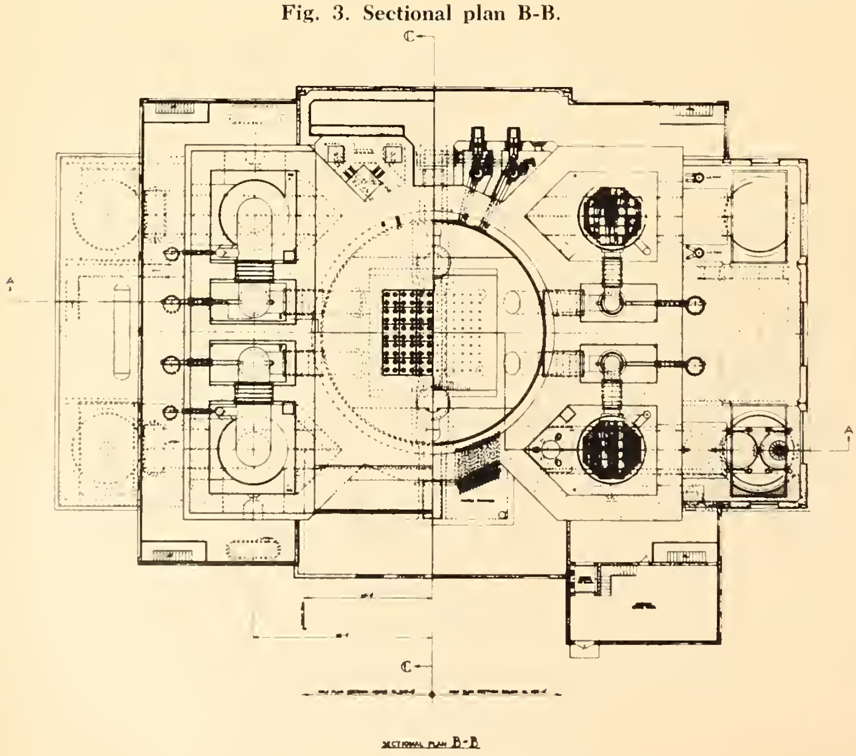


Fig. 2. Sectional elevation A-A.

Transplanting of this canning philosophy into closed circuit high temperature reactors, and using of canning materials whose value exceeds that of the uranium fuel itself, is a peculiarity of existing power reactor designs which seems unlikely to survive in central station practice.

In fairness to the British it must be admitted that since the canning of the Calder Hall type fuel elements was required to provide the necessary cooling area, it was logical to use it to contain the fission products. But in a high temperature gas cooled reactor where the only reason for canning is fission product containment, we doubt that the practice will survive the test of time.

Fig. 3. Sectional plan B-B.



The use of even a mildly active circuit requires that the heat exchangers or steam raising units be shielded, that special provisions be made for servicing such things as the main gas circulators etc., that a continuous gas purification system* be provided, and that a system of fuelling be devised that requires the very minimum number of access openings into the active circuit. The high gas temperatures that are necessary to produce modern quality steam require special design provisions if the equipment in the gas circuit is to be fabricated from carbon steel. These were the problems that faced us when we set out to design the D-B Nuclear Steam Generator.

The heart of this generator is an approximately cubical shaped (actually 36 ft. long x 38 ft. high x 40 ft. wide), graphite moderated, uranium monocarbide fuelled nuclear reactor or "pile". (See Figs. 1, 2, and 3). The size chosen was the largest for which there was precedent, i.e. the maximum

*This becomes a part of the Scavenging System—See Addendum.

size that would fit into a 70 ft. diameter sphere. We found that the higher operating temperatures possible with such a pile would permit a heat output of 1,200 Mw. With modern turbine efficiencies this is somewhat more than enough for a gross electrical capacity of 460 Mw. which will give a net sent-out of 400 Mw. (E). The pile itself differs from the Calder Hall type by virtue of having horizontal rather than vertical fuel elements although it does have vertical cooling flow. This is the first and a very important novel feature of the design.

Horizontal fuel elements were chosen in preference to vertical ones because ceramic fuel elements are inclined to be brittle and thus cannot be easily loaded into the reactor from the top (in tension). The only alternatives therefore are vertical fuel elements with bottom charging or horizontal continuously supported fuel elements. We chose the latter as bottom charging machines seriously compromise the pile support structure and vice versa.

Fig. 4 shows that the pile itself is an assembly of the three basic types of graphite blocks. This results in a pile which has horizontal through-holes for the fuel elements, arranged on an 8 in. square lattice, with a series of vertical sinuous passages through which the cooling gas (helium) flows upwards from the bottom to the top. At regular intervals (32 in. centres), the moderating blocks have large vertical holes to accommodate 120 vertical control rods. The complete pile is prevented from collapsing outwards by a restraining structure, a portion of which can be seen in Fig. 2. This is assisted during operation by the positive pressure differential which exists between the outside and the interior of the pile. The fuel elements themselves, or slugs as they are called, (see Fig. 5) are pushed through the horizontal holes in the pile by the Charge-Discharge machines which will be described later.

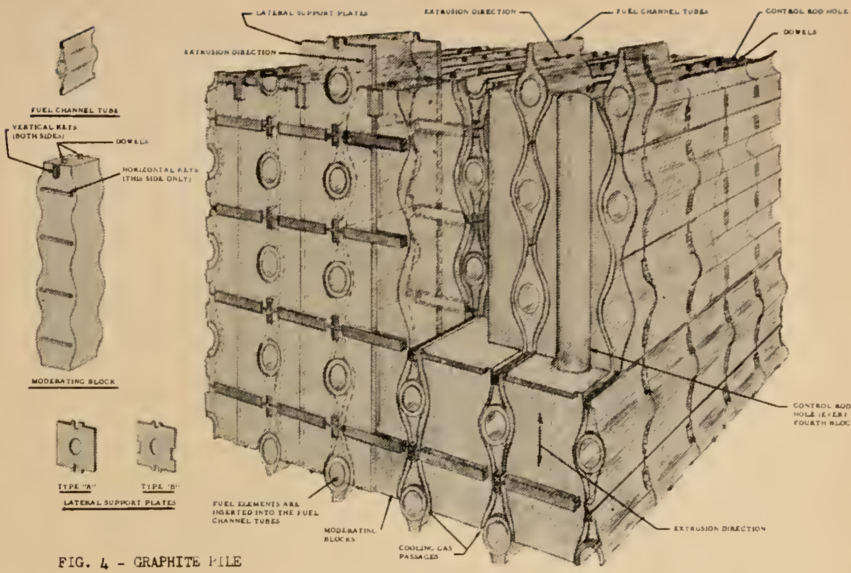


Fig. 4. Graphite pile.

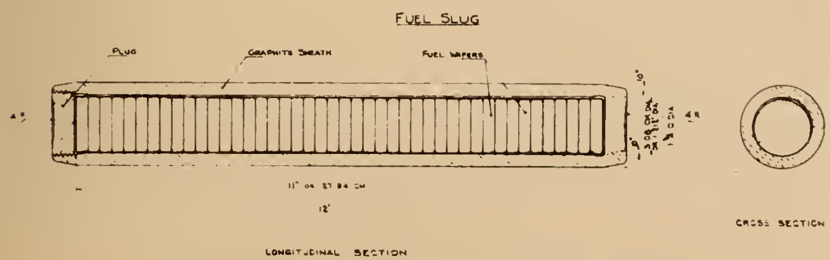
The fuel elements, which are 12 in. long and 1¾ in. outside diameter, are made of ¼ in. thick uranium monocarbide wafers contained in porous graphite sheaths. Obviously, differential expansion clearances must be provided between the fuel wafers and their sheaths as well as between the outsides of the sheaths and the horizontal pile holes into which the slugs are charged. However, this must be done without seriously affecting the flow of heat from the fuel wafers to the helium cooling gas on the outsides of the fuel channel tubes. It is accomplished by means of a rather simple arrangement which is the second and equally important novel feature of the design.

In Fig. 6, which is a cross section of two fuel elements in their fuel channel tubes, the fuel wafers are in the centres. They are surrounded by the graphite sheaths which in turn are surrounded by the fuel channel tubes. The helium coolant flows around the outsides of the fuel channel tubes from the bottom to the top. If the fuel wafers were truly circular and of a smaller diameter than the hole in the graphite sheath, then line contact between the two is all that could be expected. However, if the peripheries of the fuel wafers comprise the arcs of three circles, each having the same radius as the bore of the graphite sheath but with different centres, then each wafer must contact the bore of the graphite sheath for 120° of arc. As there are 44 fuel wafers in each slug, the average effect will be that the fuel wafers will contact the bottom third of the graphite sheath. Further, it will be appreciated that with this design, as large a clearance as required can be left at the tops of the wafers without adversely affecting the bottom contact.

A somewhat different arrangement is used to ensure good thermal contact between the outsides of the fuel slugs and the bores of the fuel channel tubes. The outsides of the fuel slugs are made circular while the bores of the fuel channel tubes have troughs machined in them which extend over the bottom 120° of arc. These troughs have radii equal to the outside radii of the fuel slugs. Thus the slugs will settle into the troughs and good thermal contact will result.

Heat transfer calculations based on this arrangement and using appropriate contact areas, film coefficients and material conductivities, indicate that adequate heat transfer will be obtained, that 75% of the heat flows through the lower half of the assembly with 25% going through the upper half, and that the maximum

Fig. 5. Fuel slug.



fuel temperature within the pile will be of the order of 2,900 °F. at full load with a corresponding fuel slug surface temperature of 1,800 °F.

Since the calculations for the above were made, information from Germany has indicated that the decrease in the thermal conductivity of uranium monocarbide with increased temperature is more severe than was first thought.* The data are as yet scanty but, if true, will necessitate some fuel element redesign to maintain the above low fuel element temperature. However, little difficulty is anticipated in doing this, and two possible solutions are the use of a graphite core inside an annulus of uranium monocarbide or the use of a mixed (cermet) fuel made of uranium monocarbide and graphite.

Having evolved a satisfactory high temperature pile design, the next task was to design a gas circuit which could cope with the high temperature gas coming from the reactor and direct it through appropriate steam raising devices or heat exchangers for the purpose of producing high quality steam. By examining Fig. 2 it will be noted that the gas flow in the main circuit is upward through the pile, through the ducts to the tops of the heat exchangers (each 21 ft. 6 in. I.D. x 90 ft. high), downwards through the heat exchangers, through the single stage centrifugal blowers and from thence back to the bottom of the pile.

The steam conditions decided upon were the highest that modern central station turbines can handle, i.e. 1,050 °F. and 2,400 psiG at the throttle. However, to get as large a gas temperature drop as possible through the heat exchangers (and an equally large rise through the pile) in order to keep the gas flow and thus the pumping power to a minimum, it was decided that a dual pressure system, similar to that employed at Calder Hall, was required. The steam conditions chosen for the low pressure portions of the heat exchangers were 950 °F. and 600 psiG. The estimated quantities of steam that can be produced are 2,132,000 lbs./hr. of H.P. steam and 1,180,000 lbs./hr. of L.P. steam.

To produce the above steam and yet keep the heat transfer area in the heat exchangers within reasonable limits, fairly high gas to steam (or water) temperature differences had to be used. Thus it was decided that the helium coolant should have a maximum temperature of 1,250 °F. and a minimum temperature of 450 °F.

This top gas temperature is well above the maximum to which carbon steel pressure vessels can be subjected, and as alloy steels could not be considered because of cost, the incentive to "invent" a suitable high temperature gas circuit obviously existed. It was reasoned at the outset that if carbon steel pressure vessels were to be used they would have to be internally insulated. The choice of internal insulating material was almost obvious, i.e. it had to be something that would not "foul" the pile if it "dusted". The only material that comes within this category is commercial carbon. While this material has the same excellent thermal shock resistance as graphite, it has a thermal conductivity only one tenth that of graphite and considerably below that of magnesia at the temperature at which it will be used.

Even with internal insulation the carbon steel pressure vessels would heat up if they were not externally cooled. At first it was thought that air cooling would be adequate but it was not long before the idea of

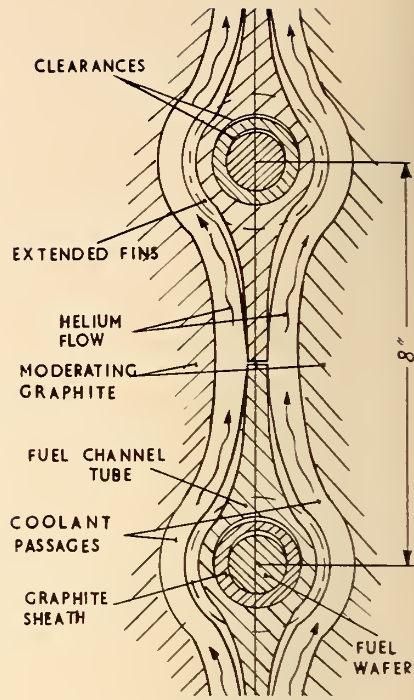


Fig. 6.

external water flooding was evolved. This came about logically and is the third novel and very important fundamental feature of the design.

With an active cooling circuit, the heat exchangers and ducts as well as the reactor itself must be shielded. This means that massive concrete shielding walls must be built around all these pieces of equipment. In short, the equipment will be housed in the equivalent of concrete tanks. Thus, it was reasoned that if these concrete tanks were steel lined (to prevent water leakage) and filled with water, the carbon steel pressure vessels would be adequately cooled with many other desirable results. One of the most important of these is that very uniform vessel temperatures can be maintained. This practically eliminates differential thermal expansion and the necessity for expansion joints in the ducts. This in turn means that the ducts do not have to be kept in one plane which results in a very compact arrangement. (See Fig. 3). This is best illustrated by stating that the building volume of a D-B Nuclear Steam Generator is somewhat less than that for the equivalent modern coal-fired boiler.

Another desirable result of this external water flooding is that it con-

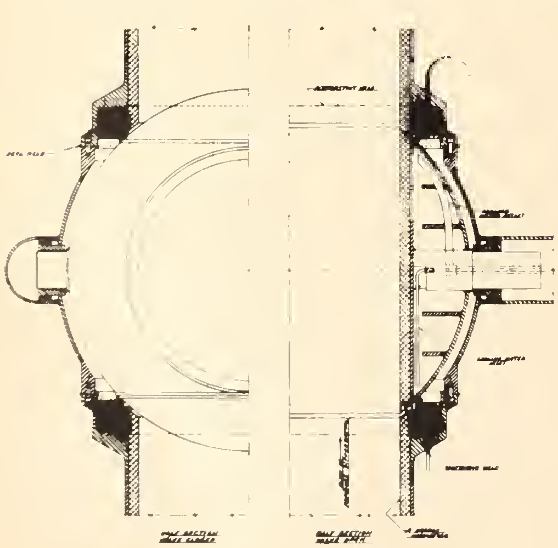


Fig. 7 Spherical helium valve.

*This has since been contradicted by a paper entitled "The Physical Properties of Uranium Monocarbide" by F. Rough (BMI) and C. A. Smith (AI) presented at the December 1958 meeting in Detroit of the American Nuclear Society which indicates that the thermal conductivity of UC improves above about 500°C.

tributes substantially to the shielding and completely eliminates the so-called "thermal shield" which in other power reactors is made of very thick steel or cast iron. Yet another is that the external water flooding permits the entire pressure circuit to be hydrostatically tested after it has been erected in place and prior to the "internals" being installed. This is a most important safety feature.

Many secondary advantages stem from this external flooding of the primary gas circuit. Among them is the fact that a higher internal gas pressure can be used. Another is that the main gas isolating valves can be of the spherical type with water cooled spheres and double seats (see Fig. 7). This renders them almost insensitive to the internal gas temperatures and means that still higher gas and steam temperatures are possible with this type of nuclear steam generator. Another advantage of the water cooling is that the actual pile support structure, which consists of hollow columns, box girders and box beams, can be internally water cooled. This structure can be seen in Figs. 2 and 10.

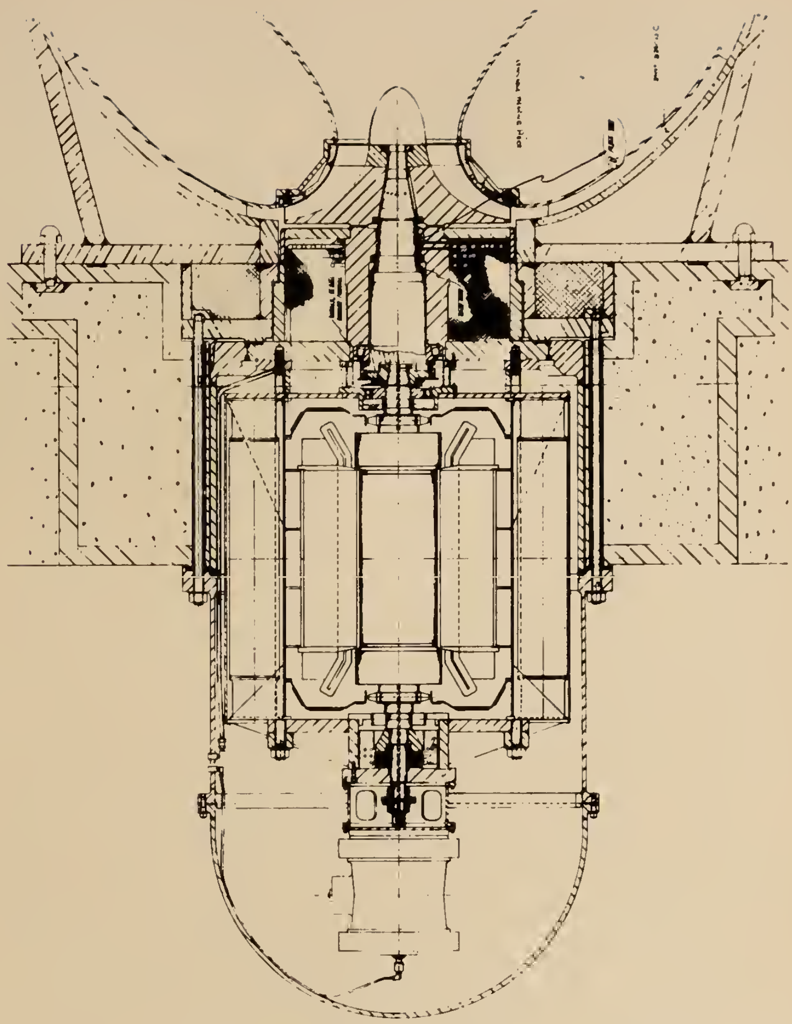
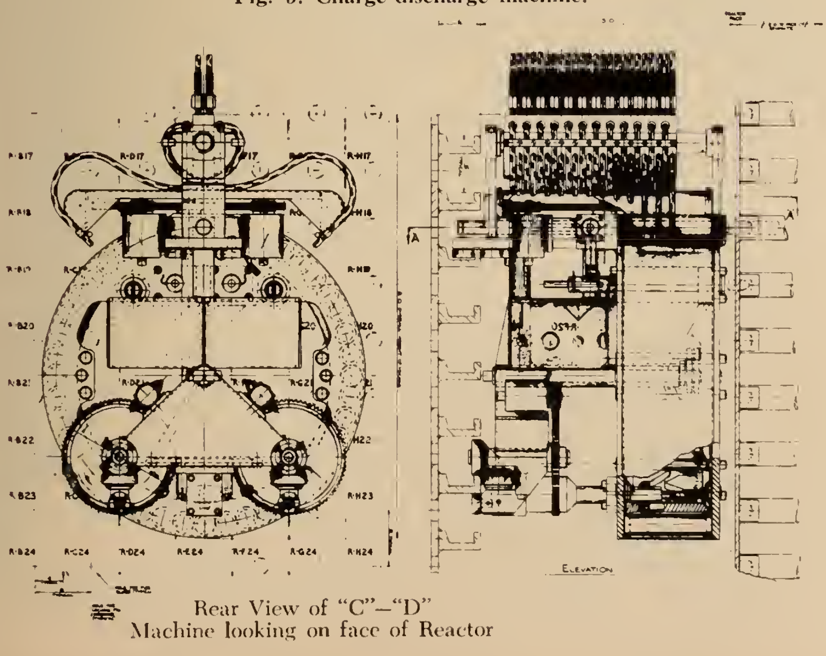


Fig. 8. Blower assembly.

Because of the active circuit special attention had to be given to the design of the main blowers and their driving motors as well as to the various other items of equipment which penetrate the active circuit from the non-active regions. The main blowers, motors and pony motors are illustrated in Figure 8. It will be observed that they are completely "canned" assemblies. Active helium can be prevented from entering the motor cans, as well as all the other gas filled devices that protrude beyond the shielding, by continuously flowing purified helium into them. This helium will come from a purification system having a capacity of 200 cfm at 200 psiG. The helium pumps used in the purification system will be metallic diaphragm CORBLIN pumps which are made in France. These are very cunningly designed affairs in which the metallic diaphragms are relieved of any stresses other than their own flexural stresses. Thus they are available as compressors in standard sizes ranging from 60 cfm, 210 psiG in one stage to 18 cfm, 3,700 psiG in two stages. The company has also made a high pressure machine having a delivery pressure of 15,000 psiG.

The method of charging and discharging the fuel slugs that was evolved for the Daniels-Boyd Reactor is the fourth important fundamental feature of the design. In tackling the problem the premise used was that the number of openings into the active circuit must be kept to a minimum. Obviously the absolute mini-

Fig. 9. Charge-discharge machine.



mum is one. The next best is two and the system which we have evolved requires only three: two inlet and one discharge. The hearts of the system (for it has two to permit bi-directional fuelling) are the Charge-Discharge or C-D machines illustrated in Fig. 9. Each of these consists of a magazine, an indexing system, a ram, a frame and appropriate wheels. All of the motions in the C-D machines are operated by 500 psi helium. The machines themselves operate on horizontal static tracks built within the reactor pressure sphere (see Figs. 10 and 11) and incidentally, only static devices remain in the sphere. All the pieces of mechanism which might require maintenance are retractable from the sphere.

The C-D machines are lowered into the sphere on track equipped dollies which run on vertical tracks extending from the elevator heads as seen in Figs. 10 and 11 down to the bottom of the pile. Each of the elevator shafts is equipped with a spherical isolating valve having double seats and as large a sphere as is required for shielding when closed. Below each elevator head is a diametrically split lead gate with hose and cable slots. These gates are kept closed at all times except when the C-D machines are passing through. The entire elevator heads are removable and are internally shielded with lead to protect maintenance personnel. When in use they are surrounded with additional removable concrete shielding to protect personnel from the radiation emanating from "Hot" slugs.

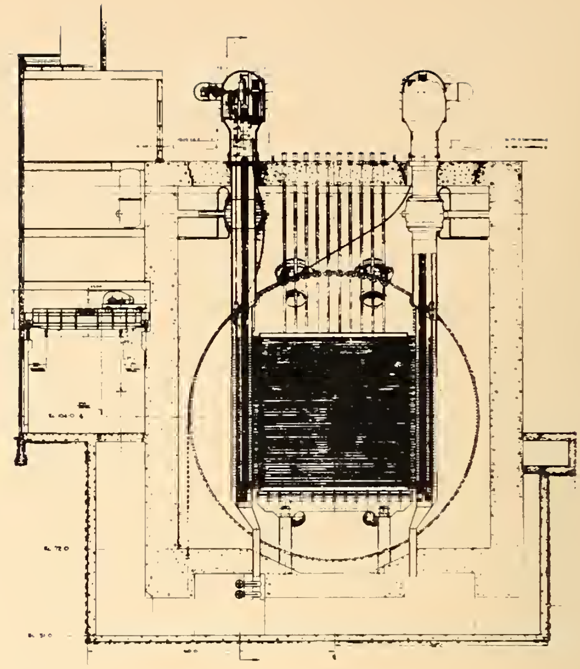
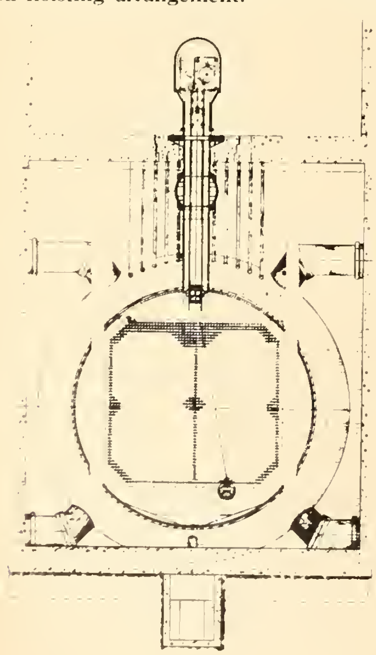


Fig. 10. Fuelling system.

An interesting feature of the elevator heads is that there are no shafts or other dynamic devices projecting through them from the active circuit. This also applies to the rest of the reactor and it is the reason why we think that the helium system can be made gas-tight. All of the active circuit joints, with the exception of the maintenance joints, are welded. All of the maintenance joints are static and are located beyond the regions of high temperature and high activity. Thus organic gaskets can be used, and we have found that such joints can be made helium-tight. Finally all of these maintenance joints face purified rather than active helium. This is a desirable safety feature should small leaks actually occur in any of these joints.

One rather important feature of the Charge-Discharge system is the method of locking the elevator dolly onto the horizontal tracks within the reactor sphere. This is done in such a way that it cannot be unlocked until the C-D machine returns to it. The device is illustrated in Fig. 12 and depends on the fact that while the dolly locking mechanism is on the dolly, the key for it is on the C-D machine. Thus, when the C-D machine has moved away from the dolly along the horizontal tracks, the dolly cannot be unlocked and withdrawn.

In operation the fresh fuel slugs, which will be shipped in helium filled, solder sealed tins similar to English cigarette tins, are loaded into the C-D machines through helium filled atmospheric glove boxes and gas locks on the two elevator heads. Spent fuel slugs are discharged from the C-D machines in the elevator heads into turning devices and thence into discharge tubes. The spent slugs slide down these discharge tubes under the influence of gravity and end up in a spent fuel slug canning machine which is enclosed in a pres-



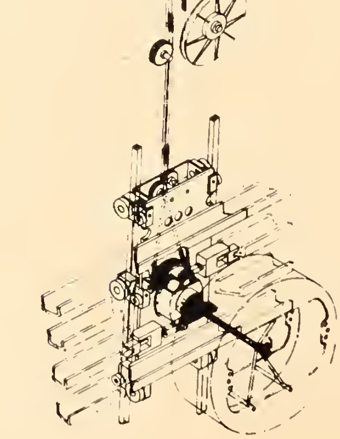


Fig. 11.—Below: Fuelling system.

Fig. 12.—Right: Elevator dolly locking and hoisting arrangement.

sure shell and operates in helium at pile pressure. In this machine the spent slugs are put into carbon steel containers (two to a container) which have end caps welded onto them. The filled containers are then discharged into a shielded flask through a helium lock. They are then transported by this flask to a surface decontaminating bath and after this operation is completed, they are put into a cooling pond for medium term storage before being sent to the chemical processing plant.

Nuclear Physics

While the engineering work on the overall D-B Nuclear Steam Generator was in progress, a series of calculations was made, with the aid of desk calculators and a Datatron digital computer, on the nuclear physics of the pile itself. Naturally, with the limited time and man-hours available, our accomplishments in this field were limited. We did, however, make calculations of optimum lattices, of the excess reactivity vs. temperature (see Fig. 13), of the effect of graphite purity and bulk density on initial reactivity (see Fig. 14) and of the probable burn-up that might be expected with this type of reactor.

It will be appreciated that because the Daniels-Boyd reactor is nothing more than a helium cooled heterogeneous assembly of uranium monocarbide and graphite (325 tonnes of UC and 2,540 tonnes of graphite) without any parasitic material, it will have as high a nuclear efficiency as it is possible to obtain with a high temperature, graphite moderated gas cooled reactor. This was confirmed by our reactivity and burn-up calculations. However, very modest enrichment was found to be necessary because of fission product poisoning and the net deterioration of the neutron reaction cross sections with temperature.

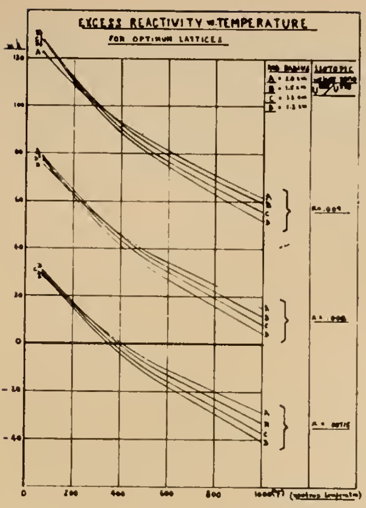


Fig. 13.—Left.

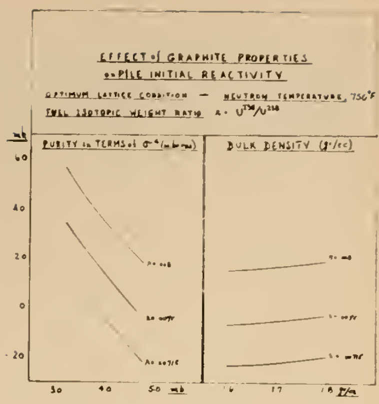
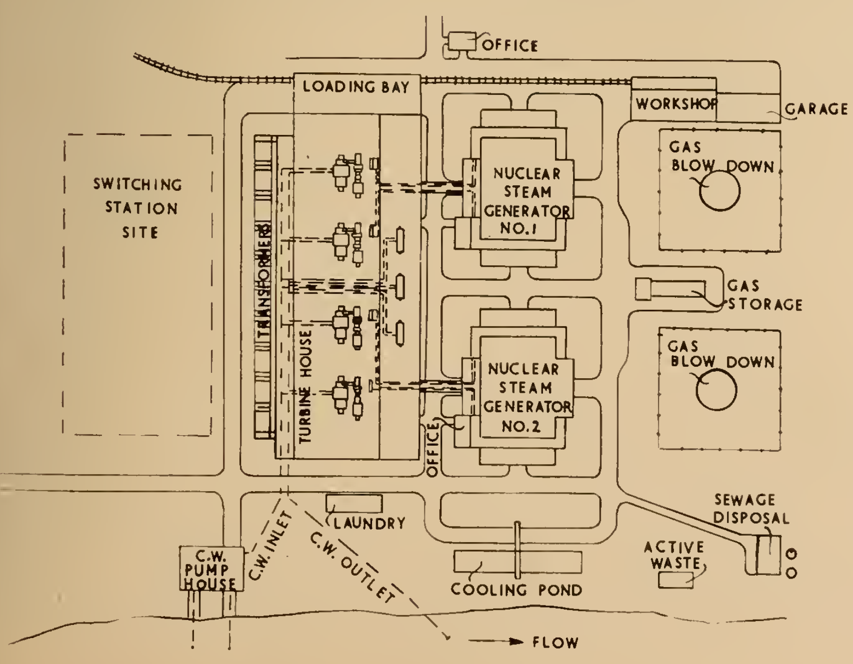


Fig. 14.—Above.

Although it was not possible to fully optimize the pile, it was calculated that for an optimum lattice with an 8 in. pitch and a fuel element diameter of 1¼ in., the isotopic concentration of U^{235} in the fuel would have to be increased to 0.75% for the reactor to remain critical after a cold, clean start. Also, preliminary calculation further indicated that a burn-up of about 4,200 MWD/tonnes could be expected with 0.8% initial U^{235} content and 9,800 MWD/tonnes with 1.0% initial U^{235} content.

Fig. 15. General arrangement of an 800 MW. nuclear power station.



Economics

Because of variations in accounting practices and financing charges, uncertainties about the cost of plutonium and similar uncertainties about the long term cost of uranium, it must be strongly emphasized that the power costs expressed in mills are not directly comparable with such cost figures produced by others.

In arriving at the figures quoted we used the following assumptions based on the most conservative practices used by the Hydro Electric Power Commission of Ontario:

Fixed charges 8½% per annum
Fuel inventory 4% per annum

An allowance of $1.00 per kilowatt per year was made for insurance and contingencies, and the operating cost was based on the figure of 0.90 mills per kwh. as given on page 128 of the Ninth Annual Supplement of the Federal Power Commission's Report F.P.C. S-127 on steam-electric plant construction cost and annual production expenses as applicable to the 500 Mw. Philip Sporn plant at Graham, W. Virginia.

In the absence of other data natural uranium was costed at the U.S. Atomic Energy Commission price of $40 per kilogram and enrichment costs were taken from the A.E.C. table of charges for enriched uranium.

A complete 400 Mw. station (see Fig. 15 which illustrates an 800 Mw. station) is estimated to cost $100 million or $250 per installed kilowatt. Of this amount $40 million or $100 per installed kilowatt represents site and plant costs equivalent to those of a coal-fired station less the boilers.

The remaining $60 million or $150 per installed net electrical kilowatt represents a preliminary approximation to the cost of the 400 Mw. (net E) Nuclear Steam Generator and its associated building and equipment.

A detailed engineering estimate indicated that the fabricating cost of each fuel slug would be approximately $21. According to one preliminary study that was made, the reactor will contain about 100,000 natural uranium slugs and about 8,000 enriched slugs. The following power cost estimate was based on this and is considered to be conservative.

A computer program, which would have determined the optimum relationship between burn-up and enrichment, was undergoing computer trials when design work was stopped. Also, detailed reactor cost estimates were well advanced at that time but experimental fuel element fabrication had not begun.

With these reservations the power cost shown in table I can be compared with about 7 mills per kwh. (based on the same costing assumptions) for the original R. L. Hearn station of the Ontario Hydro.

Also since preparing the original manuscript, it became apparent that our reactor arrangement is an ideal one for the incorporation of a gaseous and volatile fission product scavenging system. This, we found, could be added without compromising the reactor in any way and its basic design has now been completed.

Table I

Estimated Power Cost

	Mills per Kwh.
Capital charges at 8½% on $100,000,000 assuming 400Mw. Operation for 7,000 hrs. per year	3.030
Fuel inventory at 4% on $18,644,000	0.266
Fuel Costs	2.135
Spent Fuel Cans	0.042
Insurance and Contingencies—$1.00 Kw./year	0.143
Operation based on the Philip Sporn Station	0.900
TOTAL	6.516

This added feature, together with ceramic fuel, graphite moderation and helium cooling gives the Daniels-Boyd reactor great inherent safety. The vast heat sink of the graphite plus the very high melting point of the ceramic fuel renders the reactor almost completely immune to the effects of blower power interruptions and short time power excursions. In the very unlikely event of a structural failure in the main cooling circuit, a minimum amount of activity will be released to the atmosphere because the gaseous and volatile components of the fission products will have already been scavenged from the system and confined in separate containers.

On the other hand the type of gas cooled reactor now being built in the U.K. does not enjoy such safety advantages. This is due to the very small margin that exists between the operating and melting temperatures of their magnox canning. Such reactors will thus be more sensitive to blower power interruptions and short time power excursions. And in the event of a structural failure in the main cooling circuit, some of the magnox canning will most probably melt and as a result, release a portion of the concentrated fission products to the surrounding countryside. In spite of this however, the English consider their reactors to be sufficiently safe to build them in large numbers and without the American type of safety containment.

Conclusions

1. We believe that the only type of nuclear power reactor that will survive the test of time in the public utility power business, i.e. that will produce competitive power, is one which can generate steam at present day temperatures and pressures, can be made with the existing types of boiler making and heavy engineering machinery, can be made of present day engineering materials, can be safely operated by average plant personnel and *IS SELF-SUSTAINING (with appropriate chemical processing) AS FAR AS ENRICHMENT IS CONCERNED.*
2. The helium cooled, active circuit, graphite moderated, carbide fuelled, ceramic reactor appears to be the only type that will satisfy the above requirements.
3. The Daniels-Boyd Nuclear Steam Generator incorporates such a reactor and is an engineering contribution to the solution of the problem of economic public utility nuclear power.

(Continued on page 122)

Table II

Estimated Power Costs from a 400 Mw (Net E) Power Station Incorporating a Daniels-Boyd Nuclear Steam Generator

	Mills/KwH. @ 7000 Hrs./Yr. (80%)		
Type of Estimate	*0.78% U235 3000 MwD/T. 2900°F. max. fuel temp.*	*1.0% U235 9800 MwD/T. 2900°F. max. fuel temp.*	*1.0% U235 9800 MwD/T. 3500°F. max. fuel temp.*
Very Conservative	6.9	5.7(4)	5.3(3) (4)
Less Conservative but perhaps more Realistic Fuel Costs	6.5(2)	5.3	4.9(3)
Ditto and using Chalk River's Basis for Estimating(1)	6.0	4.8	4.4(3)

Power Costs Based on (except as noted)
- (a) 8½% Capital Charges.
- (b) 4% Fuel Inventory Charge.
- (c) No Plutonium Credit.
- (d) $250/Kw(E) Power Station Capital Cost.
- (e) A.E.C. Prices for UO_2 and UF_6.
- (f) Estimated Fuel Conversion and Fabrication Costs.
- (g) Estimated Spent Fuel Can Costs.
- (h) 1.04 Mills/KwH for Operation, Insurance and Contingencies.

NOTES
- (1) 7.6% Capital and 4½% Fuel Inventory Charges 0.75 Mills/KwH for Operation, Maint. and Supplies.
- (2) Figure in the Body of the Paper.
- (3) $217/Kw(E) Power Station Capital Cost & 500 Mw (Net E) Power Output
- (4) Recommended Figures to Quote for Present and Future Power Stations.

DISCUSSION

of Technical Papers and Other Articles

Magnetic Amplifier Control for Reversing Hot Mill Auxiliaries
R. L. Duke and L. R. Hulls
Canadian Westinghouse Company, Limited, Hamilton, Ont.
The Engineering Journal, 1959, July, p. 89

W. G. Wright*

BEFORE embarking upon a specific discussion of the technical points raised in the paper, I would like to make one general observation. The authors' paper is an excellent example of the care and insight which electrical engineers must use in order to enable a piece of production machinery to deliver the goods. Time was, that provided you had a starter and enough horsepower, you were in business. Now the ultimate limit on production (and hence return on investment) may well be the performance of the electrical system. The present paper demonstrates this admirably and, I might add, very lucidly.

The Canadian General Electric has never been quite so ready as Canadian Westinghouse to use push pull magnetic amplifiers for direct excitation of DC generators. Instead we have preferred to use a rotating amplifier driven by small control magnetic amplifiers. Our reasons for this are as follows:

(1) In order to get two fully rated fields on the generator we usually end up with a more expensive generator which offsets any economy brought about by eliminating the rotating amplifier.

(2) The performance of both systems may be perfectly matched to the application but we believe that the rotating amplifier circuitry is simpler for an electrician to follow. Perhaps this is a matter of how the circuits are drawn. A three phase push pull magnetic amplifier circuit with all its attendant filtering may be quite complicated. However, it may be made to look simple if these devices are drawn as blocks with input and output terminals.

(3) Commutators and bearings present a maintenance problem on the larger machines rather than small rotating amplifiers. Thus the bearing and commutator difficulties really stay with you even though the main amplifier has been made static.

(4) Since we keep our control magnetic amplifiers small (about 75 VA) we can usually make them 60 cycle. Even if we do go to a higher frequency we are able to generate this by small frequency multipliers rather than supplying a high frequency generator.

The above is a brief review of a difference in viewpoint which has been going on for some time now. It's probably really due to our respective accounting systems and so will never be resolved.

I wonder if we will get in unison again when the power generators themselves are replaced by static devices.

In conclusion I would like to ask the authors to expand a couple of points which aroused my curiosity.

(1) Referring to the block diagram we see that the feedback has a gain of 7. A typical output voltage of a bloom mill auxiliary is 500 volts. This means the input pattern is 4000. This is a very large number if it refers to ampere turns. In other words, I am saying that with a total loop gain of 7 I would expect the feedback gain to be .1 and the forward gain 70.

(2) The speed amplifier is outside the regulating loop. Are these magamps biassed to their midpoint, and if so how do you ensure freedom from drift?

(3) A time constant of 2 seconds for a 150 Kw. generator having two fully rated fields seems somewhat low. Is there anything special about this machine such as small air gap or laminated frame.

* Specialist — Metal Rolling & Processing Engineering, Systems Application Engineering, Apparatus Department, Canadian General Electric Co. Ltd., Peterborough, Ont.

G. L. D'Ombrain*

Dr. G. L. D'Ombrain of the McGill University also raised two questions from the floor and the following is our interpretation of his queries.

1. How are time constants determined by calculation or by test?

2. Please elaborate on the step or steps taken from the open loop transfer function to the characteristic equation. Is the characteristic equation derived from the closed loop transfer function?

* Professor, faculty of Electrical Engineering and Chairman of the Department, McGill University, Montreal, Que.

R. B. Cornell*

I congratulate the authors on their paper. It describes an excellent method of controlling Reversing Hot Mill auxiliaries.

The importance of prompt reversal and fast acceleration of these auxiliaries can be appreciated when we note that the mill would make about 23 passes to reduce an ingot and this would require about 190 seconds. If the time required to reverse the ingot and return it to the mill was increased by only 1 second per reversal, it would add 23 seconds to the rolling time and decrease production by 12%.

On the slide, fig. 1, four motors totalling 275 hp. are shown connected to one 150 Kw. generator. The motors are selected to accelerate the rolls and the share of the ingot that is driven by those rolls. When rolling begins, the ingot may rest on only two rolls and these must have motors powerful enough to accelerate the rolls and the whole ingot.

The table section would probably have 15 rolls, and two of which could be called on to accelerate the ingot. Therefore, all of the motors are capable of the same output per roll, but only two of them are delivering full output.

The generator is selected to supply the acutal load and not the connected load. The difference between generator capacity and total motor ratings decreases for table sections farther from the mill because when the bar being rolled becomes long enough to reach these rolls, each roll would be supporting the same share of the bar.

*Engineering Department, Dominion Foundries and Steel Limited, Hamilton, Ont.

The Authors

The reasons given by Mr. Wright for using rotating exciters rather than push-pull magnetic amplifiers for generator excitation on reversing drives merit additional comment.

1. It is our contention that magnetic amplifiers feeding directly to generator shunt fields, provides a simple and reliable device. The slight additional cost of the two field windings is more than offset by the elimination of the field exciter. This not only eliminates an item that requires regular maintenance but also saves the purchaser from supplying the building space, mounting details, starter and wiring that must be furnished for installation of additional rotating equipment.

2. With regard to simplicity, a two delay system is inherently more stable than a three delay system and therefore requires little or no stabilizing feedback. Our practice is to use single phase MAGAMPS almost exclusively and experience has indicated that filtering circuits are seldom required. These factors permit the regulator to be designed for the ultimate in simplicity and ease of calibration.

3. Any DC machine requires regular maintenance regardless of size and a multiplicity of small machines can be more trouble than a few larger units.

4. The performance can be obtained with 60 cycle MAGAMPS but where a large number of systems are required the 400 cycle supply can be justified on the basis of smaller more economical reactors, improved characteristics, isolation from mill distribution voltage disturbances etc.

The following is in reply to specific questions by Mr. Wright.

1. The system analysis is not affected by the location of the gain in the closed loop. For the sake of simplicity it has been lumped in the feedback loop in the block diagram but in the physical system it is distributed essentially as indicated by Mr. Wright.

2. The speed amplifiers are biased to their mid-point as suggested and to ensure freedom from drift they are provided with voltage feedback, which was not indicated on the diagram in Fig. No. 1.

3. The auxiliary generators have solid frames, standard air gaps and do not include any special features to obtain a low time constant. They do, however, have a small amount of series resistance as shown in Fig. 1 and this has been included in calculating the generator time constant.

In reply to Dr. D'Ombrain's question the generator time constants are determined by calculation, with occasional checks from test figures. This procedure is adequate because, if a system design depended on exact value of time constant, it would be too critical for industrial application and would be abandoned in favour of a more flexible solution.

The answer to Dr. D'Ombrain's second question would be the subject of a separate paper and we would refer him instead to a standard text on the subject. One such reference is Chestnut and Mayer's book "Servomechanism and Regulating System Design" Volume 1, page 139 under the heading "Development of characteristic equation in terms of the transfer function".

Mr. R. B. Cornell's discussion requires no comment from us but we would like to thank him and the other discussors for their interest in the paper and their contribution to the meeting.

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

Dr. S. D. Lash, M.E.I.C.* asked whether the problem had any fundamental solution applicable to all port conditions and situations or whether each port had a particular problem requiring solution.

Dr. J. A. Langford,§ commented that he had been working on the problem of erosion on the shores of Lake Ontario for many years and was glad to see some further work being done by the authors. He cautioned, however, against solutions which did not take into effect all conditions and in particular the solution of a harbour siltation problem which resulted in even worse erosion of the down-drift coast.

Mr. A. U. Sanderson, M.E.I.C.† commented that in his long experience of conditions in the Toronto region the worst erosion and drift appeared to occur during the winter storm periods. He was also of the opinion that viscosity played a major role in the rate of drift. Viscosity had an important bearing and wondered if the authors had considered the effect of building a breakwater sensibly parallel to the existing up-drift breakwater in an effort to create a venturi-flume effect which would give the littoral currents sufficient velocity to by-pass the harbour entrance.

Mr. R. F. Leggett, M.E.I.C.‡ wondered if the authors were correct in assuming that river flow into various lake-shore harbours had little effect in producing siltation.

Dr. W. D. Baines,# pointed out that the problem of littoral drift was one common to all Canadian shores, lake or ocean. Since conditions were often greatly different between such bodies of water due to the fetch distances involved the solutions themselves very often differed. He also wondered what was the real mechanism whereby littoral material did actually get inside relatively sheltered harbour areas.

Mr. J. E. Jarlan,¶ had forwarded a fairly lengthy comment which was read in part by Dr. Baines. Mr. Jarlan pointed out the importance of wind generated currents and the possible magnitude of wind set up. He added somewhat to the mathematical development of wave theory presented by the authors and stated that in shallow water the energy transmitted forward by a wave was approximately $H^2/3.5$ ft. lbs. per ft. of crest length compared to the figure of $H^2/7.0$ proposed by the authors for deep water.

Mr. Jarlan suggested that it would be interesting to have tidal or seiche recorders installed on Lake Ontario to determine the magnitude of the actual phenomenon. He mentioned also the desirability of studies of bed material movement using radioactive tracers and of wave characteristics using aerial stereophotogrammetry.

Dr. Brebner, replying on behalf of the authors thanked the meeting for the discussion raised. Mr. Jarlan had contributed a good deal of written material which the authors felt was very valuable. They had, however, since to their knowledge this was the first paper to the E.I.C. on this topic, tried to keep the material as descriptive and non-mathematical as possible. Dr. Brebner in closing replied briefly to all the points raised in the discussion.

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No. 10
of a Series

INSTRUMENTATION IN INDUSTRY

Instrumentation in the Modern Boiler Room

THE STEAM boiler has a long history going back to the eighteenth century, but it is only in the last forty years or so that the efficiency of conversion of thermal energy has shown a remarkable, rather than a gradual, increase. Much of this increase in efficiency is attributable to improvements in overall control of the many variables involved. Hand-fired boilers were common in the 1920s; today it is possible for the largest units to operate at maximum efficiency by completely automatic control of all contributing variables.

Instruments and Applications

The degree of instrumentation of a boiler plant naturally depends on its size and operating conditions. Industrial installations range from small units for heating purposes only, to those for production of process steam, to high-efficiency marine propulsion units and those used for power production via multi-stage steam turbines. The fuels used may be gas, oil, coal (and similar solid fuels) or a combination of two or more of these.

Variables which may be controlled or recorded include: rate of fuel feed; rate of air feed; feed water flow; temperatures of fuel, air, water, and steam; flue gas temperature, constituent analysis, and smoke content; plus ancillary data such as fuel and water reservoir levels.

The purpose of control instruments is largely to obtain maximum efficiency automatically, or nearly so, by constantly adjusting air and fuel supply for economy in combustion, maintaining steam pressure, combustion and exhaust pressures, temperatures, and so on. Provision is also made for transfer between automatic and manual control, and the necessary safety factors such as recording of operating faults; for example, flame or draught fan failure.

Signals from local measuring instruments may be used for several purposes (to indicate, record or control) and, by feeding the one signal or series of signals to different computing relays, two or more control functions may be carried out. After selection, the resultant outputs are transferred to controls for the operation of valves, pumps, fans, and so on.

Both pneumatic and electronic transmission of signals for recording and control are in use, and a combination of methods may be found in one plant system. Research and development work is continuing towards improvement of electrical combustion control. One aim is a simple electrical power unit which can give the same speed and accuracy as the hydraulic or pneumatic power cylinder. An advantage of the use of electrical signals is their ready application to print-out and computing circuits.

Scope of Survey

Replies from operators of steam plants in a wide field of industries indicate that it is inadvisable to try to derive definite conclusions about instrument practice in the modern boiler room from a necessarily limited survey. The sizes of plant and degrees of instrumentation vary greatly, according to the steam requirements of the industry. However, some general conclusions can be reached.

The largest and most complex boiler installations are found in the thermal-electric plants of power utilities and of industries that develop large amounts of power for their own use, for example, some of the pulp and paper and mining companies. Other manufacturing industries, in general, use steam plants for heating, driving some auxiliary equipment, such as pumps and compressors, or as a source of steam used in manufacturing processes (e.g., petroleum, chemical, food processing industries). These installations may range from small package units to relativey large capacity installations.

Requirements and Purchase

All manufacturers covered by the survey determined at least some of their own instrument requirements. However, the many package boiler units now in use are generally provided with necessary control and recording equipment as part of the package. Additional instruments may be incorporated to suit the needs of the purchaser.

Specification of instruments and recommendation of choice of suppler was reported as almost entirely the resposibility of engineering, maintenance or production department, or a combination of members of these departments.

Servicing and Maintenance

Most companies reported using their own staff to service instruments, but it is apparent that there are many instances of the use of service by the supplier or other contractor, especially where instruments are mainly to be found in the boiler plant and there would be little additional need for a permanent instrument engineer or technician.

Some form of preventive maintenance appears to be the general rule for boiler plant instruments.

The great majority of replies stated that stocks of spare parts were kept as dictated by operating experience, though some combined this practice with partial adherence to suppliers' recommendations.

As might be expected, instruments used in these boiler plants are almost entirely standard types, and are usually purchased outright.

Instrument Costs

Capital investment in boiler plant instruments could not be judged properly from the survey, but other investigatitons indicate an installed direct cost of instrumentation at $0.35 to $0.75 (approximately) per pound of steam. The figures decrease with increasing unit size (in terms of pounds per hour of steam) and vary slightly with the type of fuel used. On this basis the cost of instrumentation for a 250,000 lb./hr. steam boiler works out at about $125,000 (at $0.50 per pound of steam). Some increase in cost of instrumentation and controls is to be expected as unit size increases, since larger metering and valve equipment, and more extensive metering equipment, are usually employed. A fairly high instrumentation cost is justified by the resulting improvement in efficiency of steam generation (figures of 6% to 9% of total plant cost have been noted).

SILVER FALLS *(Continued from page 108)*

water conditions through the section where the original geological survey indicated that the rock cover was less than 75 ft. Fortunately, neither conditions were sufficiently bad to warrant interference with our normal tunnel driving procedures.

Both the shafts and the tunnel will be lined with concrete, reinforced in low rock cover sections and terminating with steel liners near the surface. The surge shaft has already been completed and the 200 ft. tank is under construction. Towards the

The invert will be poured starting end of the tunnel driving, the invert curbs were excavated with a rubber tired backhoe and poured from two 8 cu. yd. truck transit mixers which had been remounted on bogie well deck cars.

At the present time, the tunnel is being washed down, the fan pipe is being removed, tights are being drilled and blasted, and the invert is being mucked out with a small bulldozer, the mucking machine and a shielded blow pipe.

at the portal and from a 700 ft. moving bridge containing a moving screen, a rail handling device, two pumpcrete machines, a delivery conveyor and a California switch. Steel invert forms will be fixed to the curbs by embedded screw anchors.

The arch will be poured continuously from the intake and using telescopic forms and a traveller. Finally, the lining will be pressure grouted in two stages and closures made at the penstock and upper elbow of the intake shaft.

DESIGN OF A DANIELS-BOYD NUCLEAR STEAM GENERATOR *(Continued from page 118)*

4. We believe that while many of of the detail features of the Daniels-Boyd Nuclear Steam Generator will undoubtedly be changed and improved upon in the course of time, it is as fundamental to the public utility nuclear power business as Stephenson's "Rocket" was to railroading.

Acknowledgements

We would like to thank Dr. Daniels, not only for allowing us to associate his name with our project, but also for his ever ready encouragement and advice. We would also like to thank all of our former colleagues who continue to give us their help, both moral and real. Especially we would like to extend our thanks to Miss Asselin for typing this manuscript.

Addenda

Since preparing the original manuscript some further calculations of power costs have been made. These are shown in table II and are qualified by the related notes, all of which are self explanatory.

Recently the Americans have been giving considerable thought to gas cooled reactors both with and without canned fuel elements. In a recent Oak Ridge report, the following very cautious conclusion was reached for a high density ceramic fuelled, helium cooled reactor with a fission product scavenging system and an *average fuel* temperature below 2500°F: "While one cannot conclude that a reactor plant of this type will not need containment, it is quite obvious that the activity in the gas is orders of magnitude (1000 times or thereabouts) less than had previously supposed and is generally *much closer* to the clean clad system than the hypothetical case of 100% activity in the coolant".

Elsewhere in this same Oak Ridge report (TID-7564) the conclusion was reached that a stainless clad, ceramic fuelled, helium cooled reactor "will yield a substantially safer system than (the one) employed by the British and that this system does not require containment". Thus, even in the country where containment is almost a tradition, it is admitted that containment is not required for gas cooled reactors with canned fuel elements and that it may not even be required for those with uncanned fuel elements if a scavenging system is employed.

Because of this we believe that it is not unreasonable to predict that after a truly unbiased and careful study has been made of the safety aspects of the high temperature, ceramic fuelled, helium cooled, graphite moderated reactor which is equipped with an effective gaseous and volatile fission product scavenging system, the conclusion will be reached that it is inherently the safest type of reactor possible and that it will definitely not require containment.

When this has been done, the way will be clear to capitalize on the many advantages of this type of reactor which will bring truly economic nuclear power within our grasp.

Canadian Developments

The agrarian economy of thirty years ago yielded to an industrial revolution that owed much of its impetus to the country's tremendous reserves of hydro-electric power. It was the fashion in those days to speak of this resource as largely untapped. This is no longer true. The more accessible and economic sources of water power have already been exploited. While considerable hydro-electric capacity is still being developed across Canada for initial output in the near future, relatively fewer new turbines will hum with the rushing waters. Thermal electric power is getting a toe-hold in Canada today, and it is the large unused deposits of coal, oil and gas that now command attention.

Thermal power

Perhaps for this reason the naming of the Queen Elizabeth Power Station at Saskatoon* is an especially apt reminder of Her Majesty's visit to us at this particular moment in our economic history. Coal, oil and natural gas are used at the new station, and burning these three competitive fuels has stabilized fuel costs without incurring any significant additional capital expense.

Design steam conditions are 850 p.s.i.g., 900° F. and each steam generator is designed to deliver 600,000 lbs. of steam per hr. continuously and 600,000 lbs. per hr. for 4-hour peaks.

Both turbines are of the two-cylinder-tandem type with direct-connected, 3,600 r.p.m. hydrogen cooled alternators. The boilers will operate at full load on any one or any combination of the three fuels.

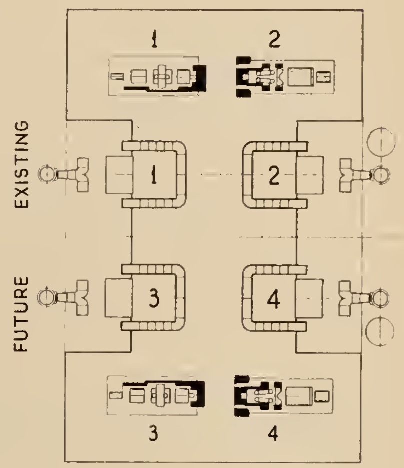
The plant layout is unconventional — the boilers will not be "in-line" but in a square formation with two turbine isles (see diagram). This layout allows a saving in building volume over the conventional arrangement.

Two sides of each boiler have been left exposed at the upper levels. There is no basement. Station auxiliaries such as pulverisers and feed pumps are at ground level. All important control and instrument panels are in a centralized location on the operating floor — not an isolated room.

All water requirements are pumped directly from the South Saskatchewan River. A buried steel pipeline delivers water direct from the pumphouse to the plant. A precast concrete pipe returns it to the river.

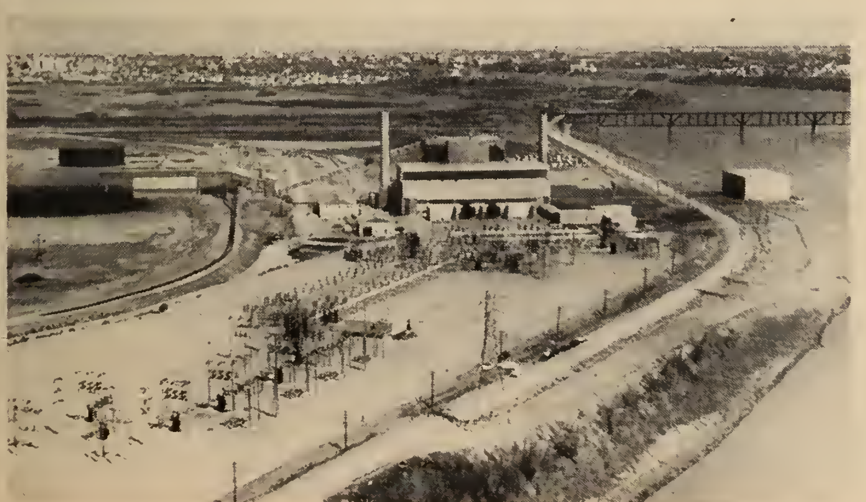
The coal-handling system consists of a rotary car dumper, belt and drag conveyors, Harding-type ball mills and other miscellaneous equipment. Provision has been made in the main building, pumphouse and fuel-handling plant for the addition of two further units of up to 100 Mw. capacity each.

With the completion of the present construction program, the Saskatchewan Power Corporation system will have reached a total capacity of over 500 Mw. by 1960, all of which is either steam or internal-combustion engine power. The Queen Elizabeth Power Station, therefore, represents 28% of that total.



Operating floor plan of the Queen Elizabeth Power Station shows the position of the ultimate four units and gives the H-shape of the building.

SET IN motion by Her Majesty Queen Elizabeth II July 22, the 141 Mw. Queen Elizabeth Power Station, situated on the South Saskatchewan River at Saskatoon comprises a switch-yard (foreground), coal handling plant (to the left) and the office block and pumphouse (to the right). The boilerhouse is on the far side of the building behind the turbine room and transformer bays.



Coal

A second large thermal plant is under construction near Estevan, Sask. — the Saskatchewan Power Corporation's Boundary Dam Generating Station. It gives an additional 60,000 kw. to the provincial power network.

The Boundary Dam Generating Station will double in size and power-output by 1960. The whole installation is similar in design to the Queen Elizabeth Power Station.

The Boundary Dam station was designed to make further use of the vast

* For full technical description of station see paper entitled "Saskatchewan River Generating Station" given before the Institute's Annual Meeting, June, 1957, by R. R. Keith, M.E.I.C., and published in The Engineering Journal, May, 1958. We are indebted to G. E. Cummings, Jr.E.I.C. and H. Kaldor, M.E.I.C. for the present information.

supplies of lignite coal underlying the Estevan area. Coal for the plant is being mined at the site.

A third 150,000 kw. unit is scheduled to be added to the Wabamun steam plant, located 42 miles west of Edmonton. The plant is adjacent to a 60,000,000 ton deposit of strippable coal and will in the future make use of it as fuel, although until now it has been burning natural gas.

Ontario Hydro's Lakeview Generating Station – reportedly the world's largest thermal-electric plant – will generate its first power in 1961. By about 1965 the six 300,000 kw. thermal generators will be in action producing 1,800,000 kw.

The plant is being built on the former Long Branch Rifle Range and an additional 25 acres of land reclaimed from Lake Ontario. Complete with enormous coal-storage yards, the station area will cover approximately 128 acres.

In full operation each of the six units will require over 100 tons of coal an hour. Thus provisions have been made for stock-piling 2,500,000 tons.

Oil and Gas

Canada's proven reserves of natural gas are in the vicinity of 23 trillion cu. ft. – about what the U.S.'s were 35 years ago. Her oil reserves appear to be almost limitless as recent strikes bring new fields to the fore in Alberta and oil drilling in the Yukon begins to spout returns.

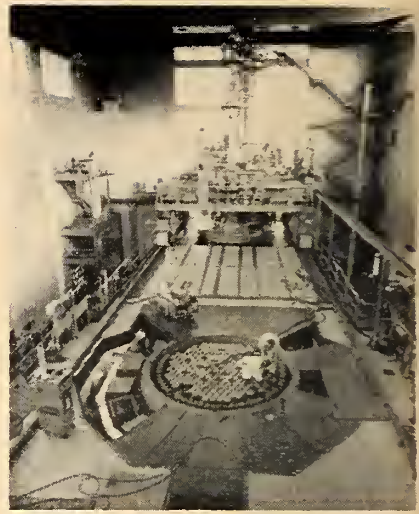
Drilling at Western Minerals Chance No. 1, 150 miles northeast of Dawson City, Yukon, and less than 200 miles south of the Arctic Ocean, brought gas and oil reserves to the surface in mid-August.

Ten thousand cu. ft. of gas per day was coming from the well at last report. Presumably it will take about two years to determine the actual extent of the resources and whether they merit commercial exploitation.

This gas-oil strike at Eagle Plain is the first in the far north since the Norman Wells Field discovery 300 miles to the southeast in 1920. The sedimentary sections in this area are comparable to the foothills and plains of central and southern Alberta, and there is good reason to hope that gas and oil reservoirs may exist in deeper horizons at the same wellsite.

The well at the time of the August discovery had a depth of 4,200 ft., 130 ft. of that giving gas and another 15 ft. of oil. The well eventually will reach 8,000 ft. in depth.

Alberta's Dick Lake field is also the site of a recent gas strike. A potential daily yield of 1.2 billion cu. ft. has been unearthed. The yield of this new 7,645 ft. well is four times greater than that of any of the other five wells in the area.



The NRU reactor at Chalk river is a triple purpose machine — it produces plutonium, makes radioactive isotopes and provides extensive facilities for research, engineering development and testing.

Nuclear Power

Ontario — **where the last 30 rivers** with hydro potential are being mapped and charted – where natural deposits of coal are negligible – has become the seat of nuclear power research in Canada. She not only needs to find a new power source to meet her needs as early as 1965, but within her boundaries lie extensive supplies of uranium waiting to be mined.

The Western provinces look to Ontario – the Maritimes watch her nuclear development with interest – all of Canada stands to benefit in the next three decades if the Ontario projects bring to light a method of power production by nuclear fission which is economically competitive with traditional hydro and thermal operations.

Atomic Energy of Canada has four nuclear power projects underway in Ontario.

The 20,000 kw. NPD-2 (Nuclear Power Demonstration) reactor at Rolphton is to be completed in late 1960 and will be hooked-up with Ontario Hydro generating stations by 1961. It will be fuelled with natural uranium oxide; cooled and moderated by heavy water.

CANDU (Canadian Deuterium Uranium), a $60,000,000 reactor which will generate 200,000 kw. (10 times NPD's output) is to be built on a 2,300 acre site on Lake Huron 9 miles north of Kincardine. It should be in full operation by the end of 1964.

The CANDU project represents a giant stride in Canadian nuclear research. This type of reactor, when perfected, should be able to operate on large baseload stations. Burning natural uranium at the rate of 8,000-10,000 Mw. days per ton, the heavy water cooled and moderated reactor is designed to reduce fuel costs considerably and eliminate the necessity of chemically reprocessing irradiated fuel.

NPD — Canada's first atomic power station.

OCDRE (Organic cooled, deuterium reactor experiment) is designed to fill two quite different functions. This type of reactor, it is hoped, could be used either in a small installation or in a 100,000 kw. project.

Since nuclear research is constantly concerned with finding a way to process uranium cheaply enough to make it a competitive power fuel, OCDRE has particular significance.

Organic liquid, rather than heavy water, is used as the coolant in this heavy water moderated reactor in an attempt to cut capital costs. With organic liquid, higher temperatures can be achieved with lower pressures. The reactor walls do not have to be so strong and building costs are diminished.

OCDRE is envisaged for certain small and medium sized sites in Northern Canada. Canadian General Electric has undertaken the contract for the 40,000 kw. plant.

Canadian Westinghouse is studying the field of small nuclear power plants. They will be necessary in Canada for two purposes — power for remote regions and a power booster for existing hydro stations.

So far the natural uranium heavy water moderated reactor appears inefficient in small sizes, and Canadians are investigating the pressurized light water or boiling water reactors used in the U.S. with enriched uranium fuel.

Both Manitoba and the Maritimes anticipate the need for new power stations of the 100,000-200,000 kw. magnitude by 1960. The utilities thus look with interest and concern upon these first nuclear projects in Ontario. Long after the rivers have been dammed and the coal beds mined there should still be uranium.

An atomic explosion may be used to release oil from the extensive deposits of tar sands in the Athabasca River region of Alberta. Heat and pressure can conceivably be used to crack the heavy hydrocarbons, making lighter products for normal crude oil production techniques to recover.

Between 200 and 300 billion barrels of oil are estimated to underlie the 17,000 sq. mi. surface area. The oil contained in the sand is highly viscous before recovery, but it cracks to a lighter form at relatively warm temperatures and does not readily return to its former state. Not all the hydrocarbon content of the tar sands will be recovered, but it is hoped that the return is adequate to compete with other liquid hydrocarbon sources.

Hamilton Falls, Newfoundland.

Hydro Power

Rivers still rush unharnessed in British Columbia and Newfoundland. These two provinces are perhaps the last in Canada to exploit their real hydro power potential. Eventually they too will be forced to turn to thermal or nuclear power — or both — to turn their turbines.

While the power of the rivers is tapped, coal, oil, gas and uranium deposits lie secretively under the great surface of the earth.

(Continued on page 188)

INTERNATIONAL NEWS

UNITED KINGDOM

Nuclear power stations are too expensive—says Sir Leslie Gamage, chairman of Britain's General Electric Company—and as a result the market for them will remain limited. Britain has a surplus capacity for atomic power station construction but the cost of building reactors is too great. Some people maintain that reactor construction in Britain could be made feasible by reducing the number of groups who are able to build reactors from the present five to three. Thus a bigger share-out of the limited demand would be available to offset gigantic research costs. Sir Leslie proposes, however, that the solution lies in finding the means to construct a less expensive reactor, thus automatically increasing demand. This will only be possible, he contends, when enrichment is available and plutonium technology is considerably advanced.

Britain's sixth nuclear power station, about to be built on the southeast coast of England, will export some of its electricity to France. The power will be conveyed by cable along the bottom of the English Channel. French hydro-electric plants, well over-stocked with electricity during the rainy seasons, can reciprocate by switching their output through the British grid.

The link-up, in operation by 1961, will be highly advantageous for both countries. Peak loads on the national grid systems occur at different times: while a full breakfast is being prepared in England, the French are making only coffee, and in the evening dinner is early in Britain, late in France.

Zeta I—the "Zero Energy Thermonuclear Apparatus"—has set up such a complicated pattern of behaviour that British scientists have decided to design a new machine to tell them more about Zeta's operation. Zeta, Britain's first step in an attempt to tame the H-bomb reaction and use its immense energy to drive power stations, must have stabilization of the great volume of electrical currents which are shot through it.

The new machine, **ICSE** ("Intermediate Current Stability Experiment"), will be much bigger than Zeta and have ten to twenty times its electricity-storage capacity. A glimmer of the research project's magnitude can be got from the fact that in order to make Zeta a paying proposition (that is, yielding far more power than is shot into it), temperature inside the machine must reach one hundred million degrees—hotter than the surface of the sun.

AUSTRALIA

The Snowy Mountains Scheme, Australia's enormous power and irrigation project of seven major dams, at least fifteen major power stations, 83½ miles of tunnels, and 330 miles of mountain aqueducts, is well underway.

In April power began to flow through 90 miles of transmission lines into the New South Wales Electricity System. The 320,000 kw. power station, 1,200 ft. underground, is now operating at full capacity.

54-kw. package power plant — "La Maignannerie" — on the Mayenne River (France).

NEW ZEALAND

A chain of ten hydro-electric stations on the Waikato River in New Zealand's North Island is nearing completion and will produce a minimum of one million h.p. of electricity. The 420,000 kw. station under construction at Benmore on the Waitaki River in the South Island will be the biggest hydro-electric station in the Southern Hemisphere. A third project—a geothermal station—is underway at Wairakei in the natural thermal area of North Island. The second station of its kind in the world, it will be producing 150,000 kw. three years from now and an additional 100,000 kw. eventually.

A shaft is being sunk in the west coast area of North Island as a result of several years' intensive prospecting by a combine of major oil companies. In addition, sizable deposits of shale oil are known to occur in South Island, Otago and Southland.

FRANCE

Package Power Plants designed by Electricite de France in cooperation with manufacturers of hydroelectric power equipment are now in operation on the by-pass canal of the Garonne River, on the Mayenne River, on the Maulde River, and on the Meuse River. They are composed of an electric generator in a sealed housing, driven by an axial-flow turbine of the propeller type. These package power plants, according to Electricite de France authorities, can be installed on pocket power projects as well as in larger installations as boosters.

Solar radiation is being collected and concentrated in large amounts at the Centre National de la Recherche Scientifique, Montlouis, France. Scientists have ascertained that while radiation on the surface of the sun equals 8 kw. per square centimeter, this same solar radiation by the time it reaches the stratosphere is only 0.135 kw per square centimeter. Their task, therefore, is to determine what can be done to recover some of that lost energy.

Scientists at Montlouis have been developing the "glass house effect" whereby the solar rays pass through a glass shield and are absorbed by certain substances on the earth. The glass shield then acts as a reflector for the rays emitted by the absorbent bodies after solar radiation has acted upon them. These rays from the absorbent bodies are much longer than those from the sun and thus give much greater temperatures.

Energy thus salvaged from solar rays and concentrated by further use of reflectors can be made to heat water, distill it, and heat air.

A large uranium oxide fritting plant which will produce two to three tons per month is now in operation near the Nuclear Research Center at Saclay. It is the forerunner of a much larger plant to be built near Paris when uranium oxide becomes more common as fissionable material in nuclear reactors.

The methods for manufacturing this material are strikingly similar to those for ceramics. The basic material, finely powdered uranium oxide, is first blended with an organic binder, then transformed into granules resembling soluble coffee. Powerful presses, exerting several tons' pressure per sq. in., compress these granules into small cylinders.

The cylinders are then placed in special kilns containing hydrogen and are brought to a temperature of 2,912 deg. F., fusing the granules into a hard, dense solid without altering the organic shape. After final inspection, the cylinders are encased in aluminum and zirconium containers and put into reactors.

202-kw. "Verdun" package power plant on the Meuse River (France).

A complex of atomelectric power plants, using natural uranium as fuel, graphite as moderator and carbon dioxide as cooling medium, is being built by Electricite de France on the banks of the Loire six miles north of Chinon. The heat absorbed by the carbon dioxide will be converted into steam to drive the classic generator units.

The project comprises three independent phases — the first producing 60,000 kw. of electric power; the second, 170,000 kw.; and the third, more than 250,000 kw.

Latest French hydro-electric power developments include the Kariba Dam on the Zambesi River; the multiple-vault dam at Migoelou in the Pyrenees; and the Saint-Vidian Dam on the Garonne, 37 miles from Toulouse.

SOUTH AFRICA

Export of uranium oxide in 1958 totalled 6,153 tons, according to the South African Minister of Mines. However, though the export totals for 1956-1958 show an increase of approximately 1,000 tons each successive year over the last, the figures for the first quarter of 1959 show a decline in export tonnage. In 1958 a total of $159,621,789 worth of uranium oxide (compared to 1957's $149,965,896) was exported to the United States, England, and Japan, most of it through the Combined Development Agency.

"Saint-Jory" pocket power project on the bypass canal of the Garonne River (France).

JAPAN

Japan's first nuclear power station is to be built at Tokai Mura, 65 miles northeast of Tokyo, for operation in 1963. The Japan Atomic Power Company has chosen the General Electric Co. Ltd. of England to build the station with the cooperation of 14 leading Japanese companies known as the First Atomic Power Industrial Group (F.A.P.I.G.).

The gas-cooled, graphite-moderated reactor will have an electrical output of 150 mw. The station, similar to the one built at Hunterston, Scotland, will be specially designed in order to ensure the safety of the installations under earthquake conditions.

UNITED STATES

A new electro-motive MU-60 peaking and reserve generating plant has been developed by General Motors Corporation. The 6,000 kw. plant is designed according to specifications laid down by public utilities companies in response to General Motors inquiries. It is portable, completely automatic in operation, unobtrusive in an outdoor setting, and can be installed for under $100 per kw. Its purpose is to supply a special power boost when the demand is at a peak.

The high-energy fuel program undertaken by Stauffer-Aerojet Chemical Company has not been affected by the recent cancellation of Air Force and Navy contracts to operate boron fuels production plants. The large-scale pilot plant at Sacramento, Calif., just completed, will begin operation immediately to develop low cost boron fuels.

The Fifth World Petroleum Congress held in New York in June drew more than 5,500 representatives from some 50 countries, among them D. S. Simmons, B.Sc., of the Engineering Institute of Canada.

INDIA

A symposium on power development

(*Continued on page 129*)

Month to Month

The Late Sir Claude Gibb Honoured

The Institution of Mechanical Engineers, London, dedicated a moment of silent tribute to the memory of the late Sir Claude Gibb on January 23. At this time, only eight days after Sir Claude's untimely death, the Institution was to have presented Sir Claude with the 1959 James Watt International Medal, awarded to "men who have attained world-wide eminence in mechanical engineering."

Sir Claude, an Australian, had made an outstanding contribution to the field of large power producing plants. It will be recalled that his paper "Graphite in the World Nuclear Power Program" was published posthumously in the July issue of The Engineering Journal.

Symposium on Reliability and Quality Control

The **Sixth Annual Symposium on Reliability and Quality Control in Electronics** is to be held at the Hotel Statler, Washington, D.C., on January 11, 12, and 13, 1960.

The symposium, initiated five years ago and sponsored by the IRE, AIEE, ASQC, and EIA, is founded on the belief that maximum reliability in electronics can only be had through research, education and free interchange of scientific knowledge and achievements. It maintains that this reliability is essential to our industrial and military organizations.

Symposium topics will include: New Mathematical Techniques; Contractual Implications; Cost Considerations; The Effect of Advanced Design and Production Techniques on Reliability; Reliability Training and Education; New Maintainability Techniques; System Aspects; Military Requirements and Specifications Now and in the Future; Reliability Prediction; New Production Techniques; Accelerated Environmental Testing; Life Tests; Failure Modes.

Increased Membership in Ontario Association

Membership in the Association of Professional Engineers of Ontario has reached 18,500, according to figures made public by their executive council in late August.

Objections to U.S. legislation

Objections to current U.S. legislative proposals regarding the Armed Services Procurement Act have been made by the National Society of Professional Engineers (U.S.A.) on the grounds that the legislation could "lead to competitive factors in the awarding of a contract for professional services."

Paul H. Robbins, executive director of the 50,000-member engineering group, testifying before the Senate Armed Services Subcommittee, emphasized that in order for the negotiation of professional consulting engineering services to conform to established practices and to professional ethics, the contracting procedure should follow two distinct steps: first, the selection of the consultant or firm deemed best qualified for the professional service required; second, the negotiation of a suitable fee with that consultant or firm.

International Congress for Bridge and Structural Engineers

The Sixth International Congress for Bridge and Structural Engineering, convening in Stockholm from June 27 to July 1, 1960, will cover six main topics: Basis of Structural Design; New Developments of Connections in Metal Structures; Steel Skeleton; New Developments in Bridge Building; Prefabricated Structures; and Important Progress in Bridge and Constructional Engineering and Composite Structures.

Engineers interested in attending the congress are asked to inform the Congress Secretariat, A.I.P.C., VI. e Congres, Box 14045 Stockholm 14, immediately.

Toronto Branch Organizes New Power Section

A newly organized power section of the Toronto Branch of the Engineering Institute will study the use of energy in all its forms.

Chaired by Dr. John Shotwell, assisted by Secretary-Treasurer Peter Killaby, the power-study group comprises men involved in every phase of the power industry — design, building, equipment manufacturing, fuel supplying, and operating.

° ° °

Montreal Section of the National Association of Corrosion Engineers, at Queen's Hotel, Montreal, November 10, "New Plastics and Their Properties".

NOMINEES FOR OFFICE

THE ENGINEERING INSTITUTE OF CANADA

The report of the Nominating Committee, as accepted by Council at its meeting held on September 12, 1959, in Saint John, N.B., is published for the information of all corporate members as required by Sections 19 and 40 of the By-laws:

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.

COUNCILLORS

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 Ontario	(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 New Brunswick	F. W. Buckley
Moncton	C. L. Trenholm
North Nova Scotia	C. V. Campbell
Halifax	J. Douglas Kline
Cape Breton	W. A. MacDonald

News of Other Societies

New Publications

The Institute of Engineers, Australia, has launched two new publications in 1959: *Electrical and Mechanical Engineering Transactions* (first issue—Volume EM 1, No. 1, May, 1959) and *Civil Engineering Transactions* (first issue—Volume CEI, No. 1, March, 1959).

Canadian Agricultural Engineering (first issue—Volume 1, No. 1, January, 1959) is to be published yearly by the Canadian Agricultural Engineering Society.

Conference Schedule

American Society for Metals, Philadelphia, October 17-21.

Ninth Annual High Polymer Forum (cosponsored by the National Research Council and the Chemical Institute of Canada), Guild Inn, Toronto, October 19-21.

National Association of Corrosion Engineers, North Central Regional Meeting, Cleveland, October 20-22.

ASLE Lubrication Conference, Sheraton-McAlpin Hotel, New York, October 20-22.

Society for Experimental Stress Analysis, 1959 Annual Meeting, Pick-Fort Shelby Hotel, Detroit, October 21-23.

Computer Applications Symposium (sponsored by Armour Research Foundation), Morrison Hotel, Chicago, October 28-29.

Institute of Radio Engineers, Radio Fall Meeting, Syracuse, N.Y., October 31-November 2.

Midwestern Meeting on New Frontiers in Aviation, Hotel Lassen, Wichita, Kans., November 2-4.

International Rubber Technology Conference on Materials Handling (ASME, ACS, & ASTM participating), Shoreham & Plaza Hotels, Washington, D.C., November 8-13.

The Chemical Institute of Canada, Chemical Engineering Subject Division Symposium, Hamilton, Ont., November 9-11.

European Federation of Chemical Engineering, Technical Meeting on Laboratory, Measuring and Automation Techniques in Chemistry, Basle, Switzerland, November 10-15.

Automation Show and Conference on Materials Handling, New York Trade Show Building, N.Y., November 16-20.

INTERNATIONAL NEWS (*continued from page 125*)

in India early this year brought out the question: Why should India bother about hydro power stations when nuclear power can be expected in five or six years? However, Dr. K. L. Rao pointed out that nuclear power can not take care of a peak load and therefore hydro has an important place in India's power development. Also India must proceed rapidly now, and the next five years will be crucial to her development.

The main obstacle which Indian scientists and engineers face at the moment in this power development effort is their dependence on other countries for the mechanisms from which power projects are built. Even small switches must be imported from an outside source. Dr. Rao spoke of the 40 kw. generator being made at Baroda and suggested that even though it appeared insignificant beside a 300-million kw. unit being produced now in Russia, it was a triumphant step in India's course toward independent manufacture and development. He urged that the Bhopal Heavy Electrical Machinery project be rushed so that transformers, switchgears, and even generators would be made in the machine shop at Bhopal within the next four or five years.

SWEDEN

A gas turbine power plant said to be the largest in the world is nearing completion on the Island of Lucerna, off the city of Vastervik on the Baltic coast. Designed for a peak-load operation of about 500 hours per year, the station will produce 40,000 kw. It is thus considerably cheaper than conventional steam power plants and its construction costs have been 25% less.

Built by the Swedish State Power Board in close collaboration with two Swedish firms — Stal for turbines and Asea for electrical equipment — the new station will use bunker oil, 495 cu. ft. per hour. It is to be remote controlled from the transformer station at Vastervik.

Final plans for the next large water reservoir at Tjaktjajaure in Sweden's arctic country have been handed over by the State Water Board to the Water Court for acceptance. They call for raising the lake's water level some 100 ft. with a dam 1,450 metres long, 100 metres high.

The $48,000,000 project should be completed by 1967, producing 150-190 mw. and allowing an annual increase of 474 million kw. in the downstream power stations' production.

BRAZIL

A 40,000 h.p. hydroelectric power plant is in operation on the Rio Paranaiba at Cachoeira Durada, State of Goias. Eventually to be a 320,000 h.p. installation, the project was designed by the mixed capital stock company "Centrais Electrica Goianias" for the state capital, Goiania, and the new federal capital, Brasilia.

SOUTHEAST ASIA

Burma, Ceylon, Indonesia, and Thailand were the objects of extended research by the International Atomic Energy Agency this year. The agency set out to determine the needs and possibilities of power development in these countries.

The Union of Burma Atomic Energy Centre will set up a nuclear radiation laboratory by 1960-61. They hope to have a research reactor installed by 1963. Burma still has unexploited hydroelectric power sources but reserves of conventional sources of energy are low.

Ceylon's National Planning Council has created a Committee on Atomic Energy and anticipates a central atomic energy authority. Ceylon needs a thorough assessment of uranium and thorium resources. She has no proven reserves of coal and oil and her hydroelectric power reserves appear insufficient for the future. Projections of likely growth in demand for power suggest that by the late 1960's installation of a nuclear station might well be feasible.

An Institute of Atomic Energy is to be founded in Indonesia. At present all work is centered in Bandung, Bogor, Djakarta and Jogjakarta. Research reactors are contemplated for Bandung and Jogjakarta. The agency mission to Indonesia concluded that before plans be developed for exploitation of the country's resources, her scientific staff and experimental facilities should be enlarged. Indonesia does have reserves of oil, coal, gas and untapped hydroelectric power, so that her need for development of nuclear power is not as urgent as some other countries'.

The Thai Atomic Energy Commission for Peace is charged with the promotion, development and control of all peaceful atomic energy activities in Thailand. The Curtiss Wright Corporation of the U.S.A. has been contracted for the construction of a swimming pool reactor with a maximum output of 1 mw. It should be in operation by early 1963.

The Yanhee hydroelectric project, supplemented by thermal power fuelled with indigenous lignite, will meet Thailand's power demands in the immediate future. However, the northeast section of the country needs industrial development and is far from power sources, so nuclear research will have to supply answers for the future.

Personals

M. Murray Dillon, M.E.I.C., has retired from the presidency of M. M. Dillon and Co. Ltd., Consulting Engineers of London, Toronto and Ottawa. He has been appointed chairman of the board.

George E. Humphries, M.E.I.C. (Wolverhampton, Staffs. '11) is the new president of M. M. Dillon and Co. Ltd., Consulting Engineers of London, Toronto and Ottawa.

M. Murray Dillon

George E. Humphries

W. L. McFaul

W. L. McFaul, M.E.I.C. (Toronto '13) has been appointed special representative in the Hamilton area for Proctor & Redfern Civil and Consulting Engineers, Toronto.

J. F. Lester, M.E.I.C., has recently retired as chief location engineer in the Alberta Department of Highways.

H. J. Stephens, M.E.I.C. (Indiana '18) has been named chief location engineer by Gordon E. Taylor, Minister of Highways, to replace Mr. Lester.

E. V. Leipoldt, M.E.I.C., has been elected to the board of directors of Canadian ASEA Electric.

Stuart R. Muirhead, M.E.I.C. (Toronto '24) will join the Okanagan Telephone Company at Vernon, B.C., as assistant to the superintendent.

C. W. Sparrow, M.E.I.C. (Manitoba '28) has been made manager of operations and engineering of Saskatchewan Government Telephones.

F. Vernon Sturman, M.E.I.C. (Berlin '29) has been appointed vice president and general manager of Gross Machinery (Eastern) Ltd., Town of Mount Royal, Que.

Stanley Adam Stannard, M.E.I.C. (Warsaw Polytechnical '32) has been appointed to the faculty of Western Ontario Institute of Technology to teach electronic technology.

C. W. Sparrow

F. V. Sturman

Guy Savard, M.E.I.C. (R.M.C. '37) was recently appointed manager, Province of Quebec region, by Canadian Liquid Air.

Dr. George W. Govier, M.E.I.C. (B.Eng., B.C. '39; M.Sc., Alberta '45; Ph.D., Michigan '49) has been named dean of the faculty of engineering at the University of Alberta to succeed Dr. R. M. Hardy. The appointment was effective July 1.

T. T. Dobie, JR.E.I.C. (B.C. '48) has been appointed design engineer III of The Consolidated Mining and Smelting Company's engineering division, Trail, B.C.

B. F. Reimer, JR.E.I.C. (B.C. '48) has been made maintenance superintendent of the phosphate plant, Chemicals and Fertilizers Division, The Consolidated Mining and Smelting Company, Trail, B.C.

Major J. J. Eatock, JR..E.I.C. (Alberta '49) is with the Department of External Affairs, United Nations Military Observer Group (India & Pakistan) for the period August 1959 to August 1960.

N. H. Booth, JR.E.I.C. (B.C. '50) has been transferred from the engineering division of The Consolidated Mining and Smelting Company, Trail, B.C., to a special assignment on iron and steel studies.

R. W. Lockie, JR.E.I.C. (B.C. '50) is the new secretary-treasurer of the Vancouver Island branch of the Engineering Institute of Canada.

J. L. P. Limbert, JR.E.I.C. (B.C. '51) is the new acting maintenance superintendent in the Tadanac Department, Chemicals and Fertilizers Division of The Consolidated Mining and Smelting Company, Trail, B.C.

R. C. Hermann, JR.E.I.C. (B.C. '52) has been transferred by Northern Aluminum Company to Auckland, New Zealand on construction of an aluminum fabricating plant.

L. H. Fransen, JR.E.I.C. (B.C. '52) has been appointed maintenance superintendent at The Consolidated Mining and Smelting Company's Bluebell Mine, Riondel, B.C.

James R. Plummer, S.E.I.C. (Queen's '58) is working with a relief organization, on loan to the U.S. Operations Mission to Paraguay, for the construction of the Trans-Chaco Highway.

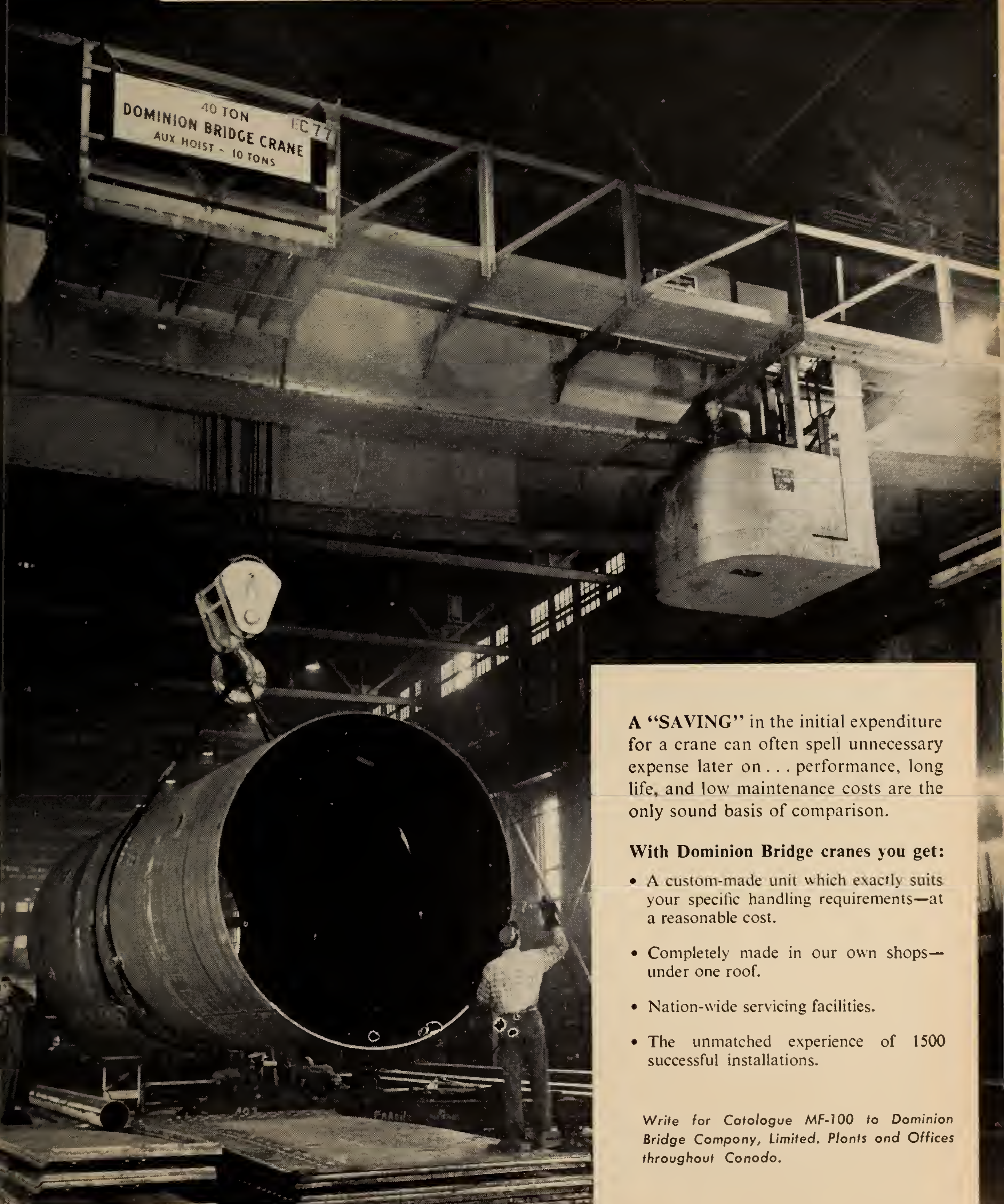
J. Edgar Dion, M.E.I.C., (McGill '26), formerly president of J. Edgar Dion & Company Ltd., management consultants, is now associated with Price Waterhouse & Co. and operating as J. Edgar Dion, consulting management engineer, Canada Cement Building, Montreal.

A. G. Macdonald, JR.E.I.C., (McGill '53) has joined Racey, MacCallum & Associates Ltd., Montreal, as an electrical engineering consultant. He has been with the Department of National Defence (RCAF), Ottawa.

G. M. Boissonneault, JR.E.I.C., (McGill '49) has been appointed assistant manager of the Shawinigan Water and Power Company's hydraulic resources department.

Howard D. Hamer-Hunt, M.E.I.C., has joined Messrs. Robert Jenkins & Co. Ltd., Engineers of Rotherham, Yorkshire, England, as site erection manager.

Investment or Expense?



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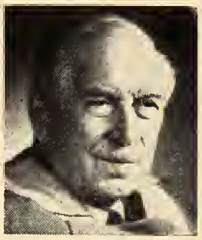
OBITUARIES

The sympathy of the Institute is extended to the relatives of those whose passing is recorded here


Charles E. Fraser, M.E.I.C.


Edmund Lancelot Miles, M.E.I.C.


Richard Francis Critchley, JR.E.I.C.

Charles E. Fraser, M.E.I.C., died at his home in Short Hills, N.J., August 23, 1959. He was 86.

Mr. Fraser was born in Montreal and received his engineering degree from McGill in 1899. In 1952 he was made an honorary life member of the McGill Graduates' Society and in 1954 the university conferred an honorary doctorate of science upon him for his outstanding work in engineering.

Moving to New York at the turn of the century, one of Mr. Fraser's early projects was the New York subway system planning. In 1908 he founded Fraser-Brace Engineering Co. Ltd. and acted as senior partner and chairman of the board until his retirement in 1955.

The company moved its operations to Montreal in 1911 and one of its outstanding achievements was the construction work on the Atomic Energy plant at Chalk River.

Armand C. Crepeau, M.E.I.C., dean of science at the University of Sherbrooke, which he helped to found, died on August 17, 1959. He was 75.

Born at St. Camille, Wolfe County, in 1884, Dr. Crepeau graduated from Laval University in 1909 as a civil engineer and land surveyor.

Dr. Crepeau began practising his engineering in Sherbrooke and represented Sherbrooke in the Quebec Legislature from 1924 to 1931.

A member of the Office of Directors of the Corporation of Land Surveyors of the Province of Quebec, Dr. Crepeau acted as its president from 1945 to 1948. He was also a charter member of the Eastern Townships branch of the Engineering Institute of Canada.

Before becoming first dean of science at the new University of Sherbrooke in 1954, Dr. Crepeau was engaged as a consulting engineer for the Hydro-Electric Commission of Ontario and later as engineer in charge of exploration work and surveying for the Department of Lands and Forests in Ungava (New Quebec).

Edmund Lancelot Miles, M.E.I.C., died September 1, 1959, in Montreal, at the age of 76.

Mr. Miles joined the consulting firm of Calt and Smith in 1909 and the following year became a junior partner in John Calt Engineering Co. Ltd. of Calgary.

Later he and John Haddin formed the firm of Haddin and Miles Ltd. of Calgary, Winnipeg, and Vancouver.

During World War I Mr. Miles was associated with the Department of the Interior in Western Canada and in Ottawa. He was engineer for the County of Victoria in Ontario from 1921-29 and in 1923 was elected a Fellow of the Royal Society of Arts, London. From 1930-38 he was manager of Standard Paving (Maritimes) Ltd. of Halifax and Charlottetown, PEI.

Mr. Miles acted as supervising engineer with the R.C.A.F. at Mont Joli Airport, Que. during World War II. He was with the Aerocrete Construction Co., Montreal, from 1945 until his retirement in 1953.

Earle Bedford Patterson, M.E.I.C., died on February 25, 1959, in Winnipeg, Manitoba. Mr. Patterson was born at Listowel, Ontario on February 22, 1883.

Upon leaving the Toronto School of Practical Science in 1909, he acted as assistant engineer at Point du Bois hydro-electric development and later as assistant engineer in charge of party for the Dominion Water Power Branch on their Winnipeg River power survey.

In 1912-13 Mr. Patterson worked as resident inspecting engineer at the La-Colle Falls Power Development of Prince Albert (Sask.). He later became assistant engineer for the Manitoba Hydrometric Survey.

Mr. Patterson was appointed resident inspecting engineer in 1930 for the Water Power Branch, Dept. of Mines and National Resources of Manitoba, at Seven Sisters Falls. In this capacity he oversaw construction of Northwestern Power Company's Winnipeg River project.

Richard Francis Critchley, JR.E.I.C., lost his life in a traffic accident at Burton-on-Trent, England, June 21, 1959. He was 26 years old.

Born in Regina on December 17, 1932, Richard grew up in Prince Albert and attended the University of Saskatchewan. He graduated in 1955 "with great distinction" in Mechanical Engineering. Richard was the recipient of the Association of Professional Engineers' prize for the "most distinguished graduate of the year in Engineering"; the Massey-Harris-Ferguson Award; and the Bowman Brothers' undergraduate award.

In 1958, after three years with Dominion Engineering Works, Montreal, he was awarded an Athlone Fellowship for two years' post-graduate study in England. While in England he did research with Vickers-Armstrong of Newcastle-on-Tyne and attended the Rolls-Royce Diesel Engine School at Derby.

Richard held a commission in the Royal Canadian Electrical and Mechanical Engineers and had been attached in that capacity to the Northumberland Hussars, Territorial Army, England.

J. Roy Freeman, M.E.I.C., died at his home in Moncton, N.B., April 18, 1959.

Born in Brighton, Ontario, April 14, 1887, Mr. Freeman graduated from the University of Toronto in 1912.

He was first employed by the Dominion Bridge Company, Montreal. From there he went to the head office of the Canadian National Railway at Moncton, where he worked until his retirement a few years ago. He was an authority on structural bridge work.

During World War I Mr. Freeman fought with the Ninth Heavy Siege Battery.

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.

*MANPOWER AND INNOVATION IN AMERICAN INDUSTRY

This study attempts to explain the expansion in utilization of executives, managerial personnel, engineers, and scientists as a function of fundamental economic forces operating in modern society. It concludes that the greater employment of high-talent manpower is the consequence of innovation and of the pace of progress in American industry, and that this trend will increase as the economic growth of America increases. (S. E. Hill and F. Harbison, Princeton, N.J. Industrial Relations Section, 1959. 85p., $2.00.)

*AN OUTLINE OF PHOTOGRAMMETRY

Translated from the German, this text gives a reasonably concise presentation of the fundamentals, methods, instruments, and results of photogrammetry from a practical standpoint. Although German instruments and methods predominate, there is an attempt to cover achievements in other countries also. Topics discussed are terrestrial photogrammetry, serial photography, plotting serial photographs with simple equipment, rectification of single photographs, stereophotogrammetry, and applications of photogrammetry. (K. Schwidefsky. Toronto, Pitman, 1959. 326p., $13.00.)

*SYMBOLIC LOGIC AND INTELLIGENT MACHINES

The principles, methods, and purposes of symbolic logic and Boolean Algebra, on which the programming of computers and some other machines is based, are explained. The material on symbolic logic contains a considerable amount of comparisons and examples, as does the discussion on machines. The designs of both small and large machines are presented, along with the specific problems involved. The programming of automatic computers and complex devices such as robots completes the book. (E. C. Berkeley. New York, Reinhold, 1959. 203p., $6.50.)

*CAREERS AND OPPORTUNITIES IN ENGINEERING

The author indicates what personal traits and abilities are needed for success in various fields of engineering and discusses educational requirements and engineering courses. The actual work performed by engineers in different areas is described as are salaries and prospects for advancement. Also included is a brief history of engineering and a chapter on the opportunities for women. (P. Pollack. New York, Dutton, 1959. 140p., $3.50.)

*ELECTRONIC WAVEGUIDES

Papers dealing with such aspects as travelling wave tubes, dynamics of electron beams and plasmas, electron plasma oscillations, propagation in ion loaded wave guides, double-stress electron beam systems, boundary conditions at the surface of a slow-wave circuit, nonlinear O-type backward wave oscillators, space and time harmonics in electron beams, and high magnetic field submillimeter wave generators with parametric excitation. This volume comprises the proceedings of a symposium held in New York 1958 and is issued as volume 8 in The Microwave Research Institute Symposia Series of the Polytechnic Institute of Brooklyn. (Ed. by J. Fox. New York, Interscience, 1958. 418p., $5.00.)

*MOLECULAR SCIENCE AND MOLECULAR ENGINEERING

In this, the third and final volume in a series on modern materials research, the fundamental molecular properties of matter and their applications derived by molecular strategy are presented. Beginning with atoms and molecules, it continues with the behavior of charge carriers in gases, the formation and structure of condensed systems, dipoles and their spontaneous alignment in ferroelectrics and ferromagnetics, and ions and electrons in liquids and solids. Among the specific applications considered are gas-discharge and solid state devices, the molecular concepts producing masers and memory systems, transducers, transistors, parametric amplifiers and ion-exchange resins. (A. R. Von Hippel. New York, Wiley, 1959. 446p., $18.50.)

*CIVIL ENGINEERING HANDBOOK, 4th ed.

A handbook, written by various authorities, which covers mechanics of materials, stresses in framed structures, steel design, highway and airport engineering, water supply, sewage disposal, and other aspects of civil engineering. In this present edition new and expanded material appears on photogrammetric surveying, interstate highway system requirements, soil classification, flow in pipes and channels, stresses in continuous beams and frames, welded steel construction, and reproportioning concrete mixtures for air entrainment. (Ed. by L. C. Urquhart. Toronto, McGraw-Hill, 1959. 1184p., $20.15.)

*LOGICAL DESIGN OF ELECTRICAL CIRCUITS

Systematic treatment of Boolean methods for analyzing relay, diode, and vacuum tube circuits, particularly as used in the design of automation systems, computers, telephone dialing systems, and similar applications. Combinational circuits, sequential circuits, and shunt-down circuits are discussed in terms of Boolean algebra, and proven methods are given for simplifying circuits. Problems in the use of relays such as those relating to speed of operation and interference between units are described in detail. (R. A. Higonnet and R. A. Grea. Toronto, McGraw-Hill, 1958. 220p., $11.50.)

*PLASTIC ANALYSIS OF STRUCTURES

Presents the techniques necessary in the analysis of structures beyond the plastic limit, and the conditions under which a plastic analysis is appropriate. The first part of the volume treats in detail the application of plastic methods to frame-type structures whose principal strength lies in their resistance to bending, and discusses such topics as elastic plastic deformations, variable and repeated loading, and direct procedures of design. The second part is concerned with combined stresses in beams, circular plates, and circular cylindrical shells. (P. G. Hodge, Jr. Toronto, McGraw-Hill, 1959. 364p., $12.10.)

*THE PHYSICS OF ELECTRICITY AND MAGNETISM

The basic theory of electricity and magnetism is treated in a rigorous manner from the viewpoint of the physicist. A modern atomic approach is used to describe such phenomena as metallic conduction and the production of chemical and thermal electromotive forces. Topics discussed are charge, field, and potential; metallic conductors; dielectric materials; steady currents; electron levels; magnetic field and materials; alternating currents; and electromagnetic radiation.

A fully descriptive and mathematical treatment is given using vector notation and intermediate calculus. (W. T. Scott. New York, Wiley, 1959. 635p., $8.75.)

°THERMODYNAMICS

The fundamental laws and terms of thermodynamics are presented from an engineering perspective. Topics discussed include the first and second laws of thermodynamics; entropy; ideals gases; availability, irreversibility, and efficiency; reciprocating machines; power and refrigeration cycles; flow through nozzles and blade passages; thermodynamic relations and equations of state; combustion; equilibrium. Tables of thermodynamic properties are included in an appendix. (G. J. Van Wylen. New York, Wiley, 1959. 567p., $7.95.)

°THE ENGINEER AND PROFESSIONAL MANAGEMENT

An introduction to management functions for the engineer beginning his career. The book is divided into two parts of which the first deals with such non-engineering functions as promotion, finance, professional management, organization, marketing, advertising, purchasing and public relations. The second part deals with such semi-engineering functions as managerial accounting and auditing, cost accounting and statistical control, estimating, valuation or appraisal, engineering economy, and industrial technologic research. (H. Rubey. Columbia, Mo., Lucas Brothers, 1958. 299p.)

°NUCLEAR REACTORS FOR POWER GENERATION

Intended for engineers who are closely associated with the building and operation of nuclear power plants without necessarily being responsible for their design. An introductory section on world energy requirements in relation to nuclear energy programs is followed by sections on nuclear physics, types of reactors, materials, the physical basis of reactor design, safety and instrumentation, and applications and economics. (Ed. by E. Openshaw Taylor. New York, Philosophical Library, 1958. 144p., $7.50.)

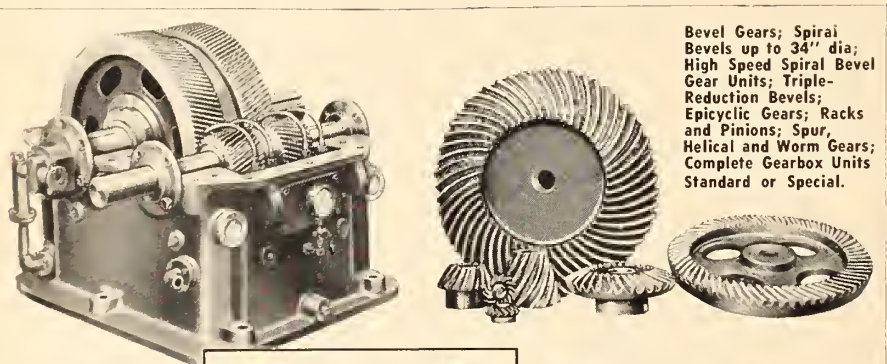
°THE ATOM AND THE ENERGY REVOLUTION

A broad introduction to atomic energy and its industrial and social implications. The author discusses world energy resources and demand, new sources of energy, the atom and its energy, methods of releasing atomic energy, sources of natural materials for atomic energy development, the exploitation of atomic energy, and political and commercial organizations for atomic energy development. (N. Lansdell. New York, Philosophical Library, 1958. 200p., $6.00.)

°ANALYTICAL TRANSIENTS

Presents the more advanced aspects of network analysis. Considerable emphasis is placed on the Laplace transformation, and on the Fourier series as a logical basis for the Laplace transformation. Attention is given to the convergence of the series, the sampling theorems, and the Gibbs phenomenon. Also included are two significant chapters, the first of which deals with the behavior of linear systems of differential equations and the influence of discontinuous driving functions upon their solutions. The second

(*Continued on page 140*)



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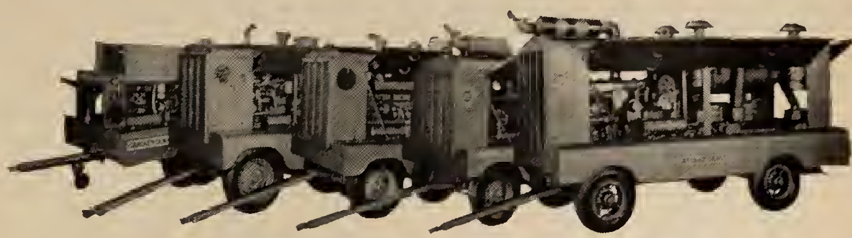

Left to right, Models RP125, RP210, RP365, RP600, RP900.

Safe, sure all-weather operation—water-oil cooling system keeps engine and compressor temperature constant.

Lubricated cold-weather starting—clutch allows compressor oil to be warmed before engaging compressor.

Positive flood lubrication—instantaneous oil flow not dependent on receiver pressure.

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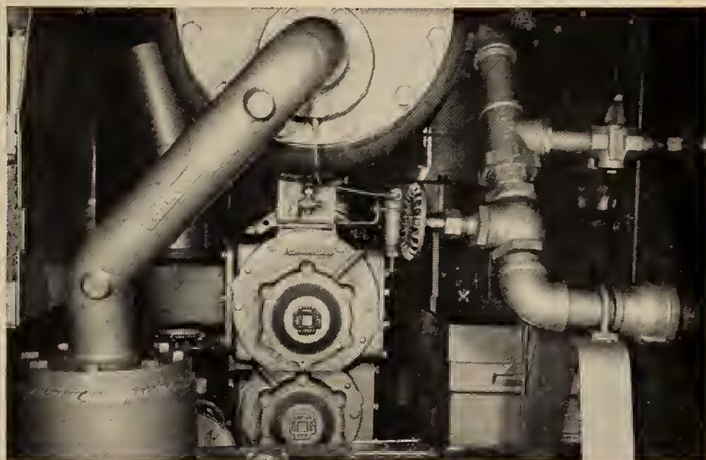
Simplified field maintenance—all compressor parts are easy to get to, making inspection and field maintenance faster and easier. See your Gardner-Denver distributor or write for bulletin.



The Gardner-Denver rotary requires no major dismantling job for inspection of working parts. Only a few minutes are required to remove the 12 cap screws to expose all the blades for routine inspection or replacement that assures trouble-free operation.

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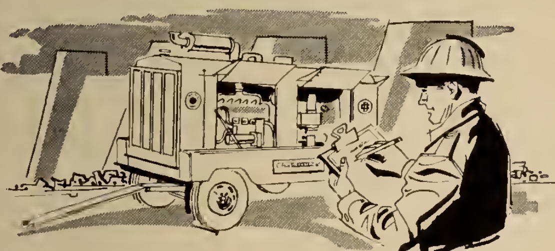

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Gardner-Denver RP900's on Glen Canyon diversion tunnel job provide trouble-free air for all phases of this major project.

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deals with stability, in which a general application of Sturm's and Routh's theorems is supplied. (T. C. G. Wagner. New York, Wiley, 1959. 202p., $8.75.)

*PACKAGE DESIGN ENGINEERING

Beginning with the basic fundamentals of static and dynamic mechanics, strength of materials, and stress analysis, the text continues with the design characteristics of the tension spring, rubber shear mount, solid cushioning, and canvas strap suspension systems. In addition the peculiarities of corrugated, sheathed crate, plywood, and metal shipping containers are discussed, as are the engineering fundamentals and design application of dehumidification and pressurization, vibration, and package test instrumentation. (K. Brown. New York, Wiley, 1959. 263p., $8.50.)

*ELECTRICAL ENGINEERING MATERIALS

The basic physical processes responsible for properties of materials are stressed in this volume, which contains sections on dielectric properties of insulators in static fields, behavior of dielectrics in alternating fields, magnetic properties of materials, conductivity of metals, mechanism of conduction in semiconductors, and junction rectifiers and transistors. Simple classical or semi-classical models are used to develop insight into the physical mechanisms described. (A. J. Dekker. Englewood Cliffs, N.J., Prentice-Hall, 1959. 208p., $8.00.)

*LINEAR NETWORK ANALYSIS

The foundations of network theory are developed in relation to steady-state and transient responses, time and frequency responses, and analysis and synthesis. Starting with basic fundamentals the authors continue with network synthesis, realizability conditions, and feedback and control systems. Specific aspects discussed include computation of network functions from any given real part, magnitude, or angle; integral relationships between real and imaginary parts; method of computing steady-state response for periodic driving functions; general treatment of classical filter theory; signal flow graphs from the point of view of directed graph theory. (S. Seshu and N. Balabanian. New York, Wiley, 1959. 571p., $11.75.)

*STATISTICS OF EXTREMES

Presents the theory of extreme values and rare events, and indicates how it may be applied to such problems as preventive measures against floods and droughts, calculating the risk involved in construction, and calculating the endurance of metals. A knowledge of calculus, analytical statistics, and prob-

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ability theory are required, although in many instances graphical procedures are used to replace complicated formulae. The book covers order statistics and their exceedances, exact distribution and analytical study of extremes, the first asymptotic distribution and its uses, the second and third asymptotic, and the asymptotic theory of the range. (E. J. Gumbel. New York, Columbia University Press, 1958. 375p., $15.00.)

°THE MEASUREMENT OF POWER SPECTRA

Review of power spectra analysis for communications engineers, digital computer designers, and statisticians. The book is divided into two parts, the first dealing with the broad aspects of the subject, and the second with certain details and derivations.

Continuous records of finite length, equally spaced records, analysis, planning for measurement, and fundamental Fourier techniques are discussed. The present edition is reprinted from the "Bell System Technical Journal" with the addition of an index and a preface. (R. B. Blackman and J. W. Tukey. Toronto, McClelland and Stewart, 1958. 190p., $2.05.)

°THE MANY BODY PROBLEM

Papers presented at the School of Theoretical Physics of the University of Grenoble. Topics discussed include the perturbation theory of many Fermion systems; nuclear structure; many body systems; nuclear matter; collective and spurious degrees of freedom in nuclear models; the Bogoliubov canonical method and its application to nuclei; electrons, plasmons, and phonons; superconductivity; the hardsphere Bose gas and the method of pseudopotentials. (New York, Wiley, 1959. 675p., $15.00.)

°HEAT TRANSFER AND FLUID MECHANICS INSTITUTE, **1959.** Preprints of papers.

Papers concerned with current, fundamental research. Sections included deal with rarefied gas flows; magnetohydrodynamics; fluid mechanics and heat transfer; ablation, mass transfer, and separation; new and unusual research. These constitute preprints of papers given at the Institute held at the University of California in Los Angeles. (Stanford, Univ. Press, 1959. 243p.)

°ENGINEERING AND ORGANIZATION

The goals of engineering are defined and the standards by which its performance can be evaluated are established. The greatest portion of the book is concerned with the place of the engineering process within the over-all structure of an industrial enterprise, and discusses such aspects as management, product specification, budget, design, production, selling, buying, maintenance, and personnel. The author is primarily concerned with

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fundamental principles as a basis for establishing standards, rather than with present-day practice. (E. Laitala. Toronto, General, 1959. 391p., $7.95.)

***HANDBOOK OF THE ATOMIC ENERGY INDUSTRY**

Provides a broad summary of the atomic energy industry throughout the world. Included are training and education; atomic structure; nuclear fuels and reactors; metals used in atomic energy; industrial, biological, and agricultural uses of radiation and radioactive isotopes; radiation hazards and protection; the handling of radioactive isotopes; radioactive waste disposal. (Ed. by S. Jefferson. Toronto, British Book Service, 1958. Various paging, $8.00.)

***DISPOSAL OF RADIOACTIVE WASTE**

Provides information relating to the basic data on which the safe limits for radioactive discharge are considered. Discusses the formation and nature of radioactive waste, the biological effects of radiation, discharge to the natural environment, and the treatment of airborne wastes, liquid effluents, and solid wastes. The problems likely to arise in the future and the means of coping with them are considered, as is the utilization of individual fission products. (K. Saddington and W. L. Templeton. Toronto, British Book Service, 1959. 102p., $4.50.)

***STATISTICAL QUALITY CONTROL**

Written for management personnel who wish to familiarize themselves with statistical quality control without the necessity of mastering the mathematical details of the technique. Following an introduction to the concepts involved and their place in management, the basic tools are then described including statistical concepts, process capabilities, statistical control charts, and statistical acceptance sampling. The book concludes with the methods used for investigations and their field of application and limitations. (D. H. W. Allan. New York, Reinhold, 1959. 129p., $3.50.)

***WORK MEASUREMENT**

The need for better planning is stressed in this volume which discusses the setting of work standards and how to use and maintain them. All phases of the work measurement program are presented: why work is measured and what it means to company personnel; the standard data approach; the economics of work measurement; the consultant's role; labor relations and work measurement. The methods and procedures described were developed from the first-hand experience of management consultants and industrial engineers actively engaged in the field of work measurement. (V. H. Rotroff. New York. Reinhold. 1959. 203p., $4.85.)

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*THEORY OF BEAMS

Discusses the application of the Laplace Transformation method to the solution of the ordinary differential equations which occur in the theory of beams. Solutions are obtained for beams on two supports under various conditions of end fixing as well as for continuous beams both with rigid and elastic supports. In addition the author derives a solution of the differential equation of the elastic curve for the case of a beam with variable rigidity and defines the load function for this case. (T. Iwinski. New York, Pergamon, 1958. 85p., $3.50.)

*ANALYSIS OF LINEAR SYSTEMS

A detailed presentation of the two essential steps involved in the analysis of a linear physical system: the setting up of the mathematical equations that describe the system in accordance with physical laws, and the solution of these equations subject to appropriate initial or boundary conditions. In the formulation of the equations that describe a physical system, emphasis is placed upon electrical circuits. To deal with systems other than electrical, a chapter on analogous systems is included which treats in detail methods for drawing electrical circuits analogous to linear mechanical and electromechanical circuits. The Laplace transform method of solving linear differential and integrodifferential equations is stressed. (D. K. Cheng. Reading, Mass., Addison-Wesley, 1959. 431p., $8.50.)

*TIGNES

This group of papers by engineers connected with the work, covers fully the hydraulic installations of Tignes in the French Alps. The Tignes Dam, one of the highest in the world is described in detail, as are the problems encountered in its construction. The power plants at Brévière, Le Chevril and Ponturin, and the central plant at Malgovert are similarly treated. The book is profusely illustrated with photographs and diagrams. (Paris, Hoüille Blanche, 1958. 440p., 8000 fr.)

*STAUANLAGEN UND WASSERKRAFTWERKE. Teil 1: TALSPERREN, 2d ed.

Part I of a three-volume set on hydroelectric power plants, this volume gives a concise but comprehensive description and analysis of the various types of modern concrete gravity, arch and earth dams, with a wealth of illustrative sketches and photographs from existing installations. Auxiliary structures and equipment are also shown, and there is a bibliography of over 1200 items. Considerably enlarged from the previous edition. (Heinrich Press. Berlin, Ernst, 1958. 395p., 54 DM.)

*MASTGRUNDUNGEN FUR FREILEITUNGEN, FAHRLEITUNGSANLAGEN UND BAHNSPEISELEITUNGEN

A manual for the design of concrete pole foundations for high-tension overhead lines, trolley wire installations, and railway feeders. It provides a comprehensive treatment of the calculations involved in designing the most economical foundations, including numerous graphs for rapid determinations. (M. Suberkrub. Berlin, Ernst, 1958. 124p., 19.80 DM.)

*BEWEGUNGSFUGEN IN BETON- UND STAHLBETONBAU

Dealing with expansion joints in concrete and reinforced concrete construction, this book discusses the importance of such joints and gives more than 300 examples of the design and construction of buildings and other structures incorporating them: silos, tanks, swimming pools, bridges, harbor works, pipelines, roads, tunnel and mine structures, etc. (A. Kleinlogel. Berlin, Ernst, 1958. 272p., 34 DM.)

*DIE BERECHNUNG DER ZYLINDERSCHALEN

Following the opening chapter on the fundamentals of shell theory, the author devotes each of the subsequent chapters to the calculation of full or partial cylindrical shells under various conditions. Particular attention is paid to barrel roof construction. The author uses the "model-shell" concept as a basis. There are over 200 references in a selected, chronological bibliography. (A. Aas-Jakobsen. Berlin, Springer-Verlag, 1958. 160p., 22.50 DM.)

°THE DESIGN OF PRISMATIC AND CYLINDRICAL SHELL ROOFS

Simplified methods of design are given for prismatic and curved cylindrical shells of any geometric form, under varying conditions of loadings, support and continuity. The structure is split into compatible elementary structures, and these are designed by elementary methods based on the theory of structures. Approximation methods are applied throughout, and only a small number of linear equations have to be solved. Fully worked out examples illustrate the application of the methods described. (D. Yitzhaki. Amsterdan, North Holland, 1958. 253p., 42 guilders.)

°CIRCUIT THEORY OF LINEAR NOISY NETWORKS

Discusses a method of determining the single-frequency noise performance of an amplifier and its optimization. The properties of linear noisy networks that are invariant under lossless network transformations are analyzed. These invariants are determined for multiterminal-pair networks, and their physical interpretations in terms of a generalized "available power" are presented. The invariants are then considered for the special case of a linear two-terminal-pair amplifier, and are shown to establish a lower limit on its noise performance. Various ways of achieving this limit are presented for all classes of amplifiers, including those with negative resistance. (H. A. Haus and R. B. Adler. New York, Wiley, 1959. 79p., $5.00.)

°THE ALGEBRA OF ELECTRONICS

Reviews the mathematical principles involved in the solution of problems in the field of circuit theory and design. Starting with graphs of networks and the relation of Kirchoff's law to Ohm's Law, the author continues with loop-branch relations in tabular form, model analysis determinants, Laplace's expansion of determinants by cofactors, solution of simultaneous equations, and Fourier waveform analysis. Applications to specific problems are considered and include series tuned circuits, impedance matching, amplifiers, noise, and modulation, demodulation, and distortion. (C. H. Page. Toronto, Van Nostrand, 1958. 258p., $9.75.)

°DECISION-MAKING AND PRODUCTIVITY

The author attempts to show that major alternatives in industrial decision-making exist and have discernible effects on productivity. He also attempts to define some of the opportuniites that exist for accelerating the growth of productivity. The book is divided into four sections covering alternative methods for productivity growth, decision-making by the union, decision-making by management, and the effects of union and management decision-making on productivity. (S. Melman. New York, Wiley, 1958. 206p., $7.00.)

BOOK REVIEW

EARLY ENGINEERING EDUCATION AT TORONTO 1851-1919

Usually the record of current events which ultimately makes up a history, is not good enough to well serve the purpose. Histories as such are written by people who come after the events and who frequently have only the fragmentary and frequently inaccurate writings of an earlier people upon which to base their story. Such historians, too, are frequently biased so that their interpretations of the record may well vary from historian to historian, as can be seen readily in histories of nations and races.

Canadian engineers are fortunate that within their midst there is a man who has the patience, the understanding and the ability to seek out the early developments in engineering education in Canada and to do it before the events become obscured by the passing of time. Such a man is Dr. Clarence Richard Young, consulting engineer, educationalist, author and historian.

This volume is Dr. Young's latest publication. It is a fascinating and well documented story of the early thinking of Canadian educationalists on the question of providing a course of a technological nature in the Province of Ontario.

The story should be interesting to all Canadian engineers but in particular to those who passed through the halls of the "School" at the University of Toronto. Dr. Young has searched the written record for a multitude of details, and has drawn on his own knowledge gained from contacts with many of the pioneers in the field of education. The result is a story which is complete, accurate and readable. As the title suggests, it relates principally to the University of Toronto, but as well it includes many references to other Canadian universities and provinces.

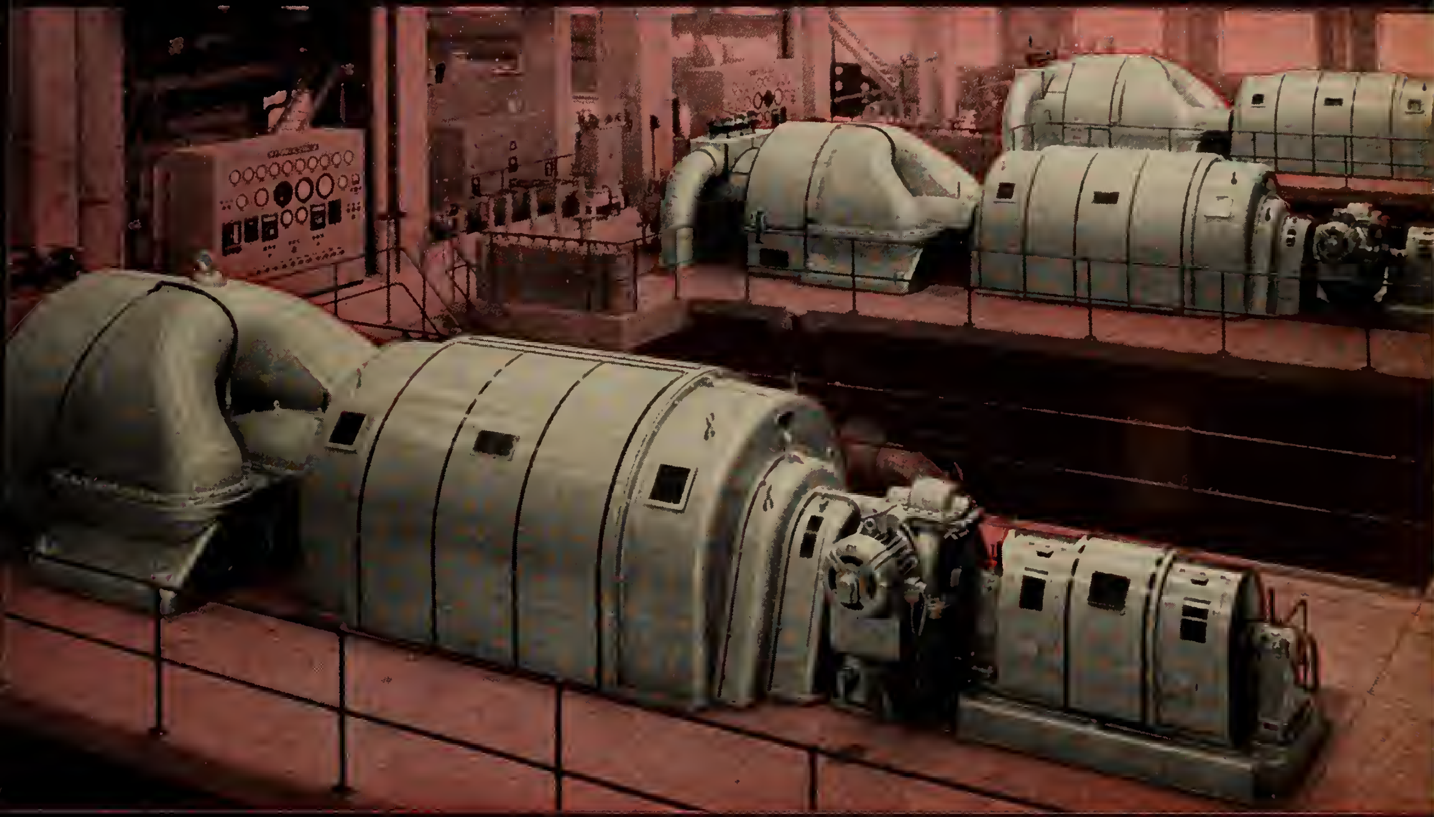
As would be expected, a history of this kind would have to be a biography of those stalwarts who fought hard and long for the establishment of technical education. Dr. John Galbraith, the founder of engineering education at Toronto, and his close associate, Dr. W. H. Ellis, have already been recognized as great men, but with the presentation of this detailed story of their struggles and success they grow even to greater stature. The profession is indeed indebted to them, and to Dr. Young for seeking out the story and presenting it in such excellent form.

Many other important early engineers are woven into the story such as Cumberland, Marshall, Herrick, Armstrong, Brydone-Jack, Cregan, Chapman, Fleming, Keefer, MacDougall, Thomson, Croft, Tyrrell, Stewart, Dawson and others.

Few members of the engineering profession in Canada write as well as does "C.R.". It is a delight to go through these pages, not only because the story is interesting but because it is so well told —and in such good English. It would

(*Continued on page 150*)

Power behind Scottish



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make excellent required reading for any student or young engineer.

To illustrate the philosophy of some of the educationalists of those times, and their opposition to anything practical, Dr. Young quotes the president of King's College, of Fredericton, N.B. (now University of New Brunswick), who in 1851 said: "To those who would make the college a polytechnic institution we may not promise much more in the way of merely practical teaching; we must not listen to the cry that calls us from the pursuit of truth and virtue to the lower paths and grosser occupations of the multitude." What would he say if he knew that today practically fifty per cent of the enrollment at the University of New Brunswick is in engineering?

To show there were others not so narrow in their outlook, Dr. Young quotes from an editorial published in a local paper: "To be intimately and critically acquainted with the writings of the philosophers, historians, and poets of Greece and Rome is a luxury confined to the aspirations of the few—not a necessity for the many. The many of this fast and labouring epoch look for knowledge that contributes relief to the wants, and will meet the exigencies of the passing hour. Mental life in a new country cannot afford the time required to detect the subtleties of the Areopagitica, or to elaborate the conceits of a Sappho, or wade through the nonsense of a fabulous mythology. The present is overloaded with the practical."

In addition to being distinguished as an educationalist and an author, Dr. Young has served and been honoured by many organizations. He was president of The Engineering Institute of Canada in 1942, was made an honorary member in 1949, and received the Sir John Kennedy Medal in 1951. He retired from the deanship of the Faculty of Applied Science and Engineering at Toronto in 1949 after serving there for over forty-two years. Since then he has continued his consulting practice with great success.

"Early Engineering Education at Toronto 1851-1919" is a real addition to the all too limited volume of Canadiana. (Toronto, University Press, 1958. 152p., $3.95.)

L. A. WRIGHT, M.E.I.C.

PEACEFUL USES OF ATOMIC ENERGY, 2ND INTERNATIONAL CONFERENCE. PROCEEDINGS.
V.8, NUCLEAR POWER PLANTS, PART 1

The official Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy are now being issued by the United Nations. This eighth of thirty-three volumes covers sessions G-3, G-6 and G-7.

The first of these heard seven papers on experience with operating nuclear power plants in the United Kingdom, United States, France and the Soviet Union. The second session was concerned with the use of nuclear energy for purposes other than the generation of electricity, and included papers on the Russian ice-breaker Lenin, the U.S.A.'s N.S. Savannah, the Japanese submarine atomic powered tanker, nuclear propulsion for ships, nuclear energy for heating, and the use of nuclear energy in industry.

The third session heard reports on future construction plans for nuclear power plants in Canada, Czechoslovakia, France, Italy, U.S.S.R., U.K., U.S.A., Sweden and Belgium. This volume also contains a Catalogue of operating nuclear reactors. (Geneva, United Nations, 1958. 584p., $14.00.)

V.12 REACTOR PHYSICS

The sixty papers included in this volume represent the majority of those presented at the Conference on this subject. The three sessions covered were concerned with fast and intermediate reactors, liquid moderated reactors, and solid moderated reactors.

Specific topics discussed include fast reactor physics, fast, intermediate and coupled reactors, fast reactor safety, D_2O and H_2O systems for liquid moderated reactors, and beryllia, graphite and com-

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posite systems for solid moderated reactors. (United Nations, Geneva, 1958. 767p., $18.50.)

°USINES DE DERIVATION

A treatise on hydraulic plants which utilize water diverted by means of canals, tunnels and pressure pipe lines. The first volume treats of water-intake systems, describing these from the point of view of climate, topography and fish protection. The formulas, equations and laws involved in calculating hydraulic construction are then discussed at length. The second volume covers forebays and pressure pipe lines with emphasis on prestressed high-pressure pipe. There are sections on water hammer, and surge tanks and the author ends the second volume with a discussion of underground hydraulic plants. (H. Varlet. Paris, Eyrolles, 1958. Two volumes. 4600; 4400 frs.)

°COST MANUAL FOR PIPING AND MECHANICAL CONSTRUCTION

The purpose of this volume is to help estimators to arrive at reliable figures as well as to provide plant maintenance managers and engineers with a means of checking estimates submitted to them. Following preliminary material on plant and service accounts, types of estimates, standard hours, direct costs, and pay statements, tables are presented on piping installation, mechanical construction, comparative unit-costs, and miscellaneous data. The tables provide unit costs calculated in man-hours, and therefore are not subject to constant changes in labor cost. (H. Herkimer. New York, Chemical Pub., 1958. 176p., $10.00.)

°TECHNOLOGIE DES REACTORS NUCLEAIRES, TOME 1 — MATERIAUX

An introduction to the fundamental concepts of nuclear technology. The effects of radiation on various materials are analyzed and classified. This is followed by a discussion of the behaviour of reactor materials, their mechanical properties and radiation damage, as well as the modification of physical properties or the formation of new substances. Nuclear fuels and non-fissionable materials provide the subject matter for seven chapters, while recent developments in uranium, heavy water, beryllium and cermets are described. (P. Ageron and others. Paris, Eyrolles, 1959. 567p., 6900 fr.)

°INTRODUCTION TO THE THEORY OF SOUND TRANSMISSION

Transmission of sound is discussed with specific application to transmission in the ocean. The fundamental relations and general theory underlying the theory of sound transmission are presented and then followed by transmission in shallow water, transmission in deep water, reflectivity, and attenuation. Mathematical derivations are developed in some detail, and physical explanations of theoretical results are given where possible. Modern advances are covered with particular emphasis on developments during the past twenty years. (C. B. Officer. Toronto, McGraw-Hill, 1958. 284p., $11.00.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Granular materials. Size determination

Review and evaluation of methods of particle size analysis, by R. F. Pilgrim. Ottawa, Dept. of Mines and Technical Surveys, Mines Branch, 1958. IC 106. 25c.

Industrial manpower

Training and recruitment of skilled tradesmen in selected industries in Canada 1951-1956. Ottawa, Dept. of Labour, Economics and Research Branch, 1957. 25c.

Instruments

British instruments; directory and buyers' guide, 1959. London, Scientific Instrument Manufacturers' Association, 1959.

Roads and streets

Flexible pavement design — research and development 1958. Wash., Highway Research Board 1959. (Bulletin 210) $1.20.

Subsurface drainage of highways and airports. Wash., Highway Research Board, 1959. (Bulletin 209) 50c.

Snow

Factors affecting snowmelt and streamflow; a report on the 1946-53 Cooperative Snow Investigations at the Fraser Experimental Forest, Fraser, Colo., by W. U. Garstka, and others. Denver, U.S. Dept.

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of the Interior, Bureau of Reclamation, 1958. $1.25.

Soil mechanics

Annual report of the Canadian section of the International Society of Soil Mechanics and Foundation Engineering for year ending June 1958; including membership list of the Canadian section, prepared by C. B. Crawford.

Proceedings of the fourth Muskeg conference, March 11, 1958. Ottawa, National Research Council, Associate Committee on Soil and Snow Mechanics, 1958. (Technical Memoranda nos. 54 and 55.)

Stabilization of soil with calcium chloride, annotated by F. O. Slate and A. W. Johnson. Wash., Highway Research Board, 1958. (Bibliography 24)

Schools

Legal liability of school boards and teachers for school accidents, by R. L. Lamb. Ottawa, Canadian Teachers' Federation, Research Division, 1959. (Research study no. 3)

Aerodynamics

Effect of standing vortex on flow about suction aerofoils with split flaps, by P. Mandl. Ottawa, N.R.C., 1959. (Aeronautical report no. LR-239.)

Aircraft

Note on the minimum power required for flight at low airspeeds, by R. J. Templin. Ottawa, N.R.C., 1959. (Aeronautical report no. LR-245).

A preliminary analysis of the penalties associated with piercing a wing torsion box with a grid of holes, by A. H. Hall. Ottawa, N.R.C., 1959. (Aeronautical report no. LR-236.)

Analysis of a cantilever beam developing an isoplastic response under impact at the tip, by A. H. Hall and V. L. Saxon. Ottawa, N.R.C., 1959. (Aeronautical report no. LR-237.)

Beams and girders

A survey of residential post-and-beam construction in greater Vancouver, 1957-1958, by V. F. Lyman. Ottawa, N.R.C., Division of Bldg. Research, 1959. (Technical paper no. 70.) 50¢.

Canada. Northwest Territories

Potentialities of the Northwest: an engineering assessment, by R. F. Legget. Ottawa, N.R.C., Div. of Bldg. Research, 1959. (Technical paper no. 65) 25¢.

Computers

Transfer-function discovery on the pace analogue computer, by J. H. Milsum. Ottawa, N.R.C., Div. of Mechanical Engineering, 1959. (Mechanical engineering report MK-2)

Construction industry

Modular co-ordination cuts design and building costs, by S. R. Kent. Ottawa, N.R.C., Div. of Bldg. Research, 1959. (Technical paper no. 58). 10¢. The technological properties of brick masonry in high buildings, by P. Haller. Ottawa, N.R.C., 1959. (Technical translation no. 792)

Fires and protection

Fire research and fire prevention; proceedings of a conference held October 1-3, 1958 in Ottawa. Ottawa, N.R.C., Div. of Bldg. Research, 1958. (Bulletin no. 2.) $1.50.

Hydroelectric power plants

The Stornorrfors power plant, by T. Nilsson. Stockholm, Swedish State Power Board, 1959. (Blue-white series, no. 19E).

The Swedish state power administration, by L. Fritz. Stockholm, Swedish State Power Board, 1958. (Blue-white series 20)

Metals and alloys

The behaviour of fine copper-nickel alloy wires with negative temperature coefficients of resistance, by W. Wiebe. Ottawa, N.R.C., 1959. (Mechanical engineering report MS-100.)

Soil mechanics

Heat and moisture transfer in closed systems of two granular materials, by W. Woodside and J. B. Cliffe. Ottawa, N.R.C., Div. of Bldg. Research, 1959. (Research paper no. 77.) 25¢.

Heat transfer in a moist clay, by W. Woodside and C.M.A. de Bruyn. Ottawa, N.R.C., Div. of Bldg. Research, 1959. (Research paper no. 79.) 25¢.

Soil engineering problems on the Quebec-North Shore and Labrador railway, by K. B. Woods, R. W. J. Pryer, and W. J. Eden. Ottawa, N.R.C., Div. of Bldg. Research, 1959. (Technical paper no. 72). 25¢

Tubes

Tube and semiconductor selection guide, 1958-1959, comp. by Th. J. Kroes. 2d rev. ed. Eindhoven, Holland, Philips, 1958. $1.50.

Vibrations

Human sensitivity to vibration, by D. T. Wright and R. Green. Kingston, Queen's University, 1959. (Report no. 7.)

Wind tunnels

Boundary layer transition on a 10-degree cone in the N.A.E. 30 - X 16-inch wind tunnel, by J. van der Bliek. Ottawa, National Aeronautical Establishment, 1958. (Laboratory report LR-232). Drag measurements on agard model 'A' in the N.A.E. 30- X 16-inch wind tunnel and comparison with other data, by J. A. van der Bliek. Ottawa, National Aeronautical Establishment, 1958. (Laboratory report LR-233.)

Notes on half model testing in wind tunnels, by J. A. van der Bliek. Ottawa, National Aeronautical Establishment, 1959. (Laboratory Report LR-235.)

REPRINTS ISSUED BY DOVER PUBLICATIONS, NEW YORK

Advanced calculus; a text upon select parts of differential calculus, differential equations, integral calculus, theory of functions, with numerous exercises, by E. B. Wilson. 1958. 566p., $2.70.

Computational methods of linear algebra, by V. N. Paddeeva. 1959. 245p., $2.15.

The dynamics of particles and of rigid, elastic, and fluid bodies; being lectures on mathematical physics, by A. G. Webster. 2d. ed. 1959. 588p., $2.60.

Elasticity, plasticity and structure of matter, by Dr. R. Houwink; with a chapter on the plasticity of crystals by Dr. W. G. Burgers. 2d. ed. 1958. 368p., $2.45.

Guide to the literature of mathematics and physics including related works on engineering science, by N. G. Parke III. 2d. rev. ed. 1958. 436p., $2.49.

An introduction to Fourier methods and the Laplace transformation, by P. Franklin. 1958. 289p., $1.65.

Introduction to symbolic logic and its applications, by R. Carnap. 1958. 241p., $2.05.

Linear groups with an exposition of the Galois field theory, by L. E. Dickson. 1958. 312p., $2.15.

Meson physics, by R. E. Marshak. 1958. 376p., $2.15.

Theory of functionals and of integral and integro-differential equations, by V. Volterra. 1959. 221p., $1.95.

The value of science, by H. Poincaré. 1958. 147p., $1.50.

CHIEF ENGINEER. Large Toronto Structural Steel Fabricator and Erector is seeking an experienced engineer with outstanding capabilities who has held a position of responsibility. This key position offers an excellent opportunity for advancement to a man who has considerable experience in the design of buildings and bridges. Applicants must have professional standing in the Province of Ontario. Salary commensurate with ability. Replies held in confidence. Please write to us giving detail of age, education, experience to File No. 6823-V.

CIVIL ENGINEER with experience in construction and municipal works required by Buildings and Grounds Department of a University in Western Canada. Duties to include estimating, supervision of construction, assist in planning of operations, maintenance and expansion of buildings and utilities. Salary range $6600 - 7800, pension and other benefits. File No. 6833-V.

STRUCTURAL ENGINEER required by expanding Edmonton firm. Work would consist of designing and client consultation with opportunity for executive appointment. File No. 6834-V.

GENERAL SUPERINTENDENT REQUIRED by general contractor in Eastern Ontario City. This man must have a proven record of performance on building contracts in excess of one million dollars and be capable of directing the work of several job superintendents with the utmost economy. Applicant must be capable of dealing with architects and engineers and settling matters with considerable dispatch. Graduation in civil engineering would be preferable but not mandatory. Top salary and good future prospects for the right man. Replies treated confidential. File No. 6837-V.

ESTIMATING ENGINEER required for Toronto district, heavy construction firm. Civil engineer preferred, age 45 to 65, interested in full time estimating work with background of experience in road building and municipal work. File No. 6840-V.

SENIOR STRUCTURAL DESIGN ENGINEER required by consulting engineering firm in Southern Ontario. Applicants must have 8 - 10 years' experience of which 6 - 7 years should have been on the design of industrial, commercial and institutional buildings. First-class structural steel design experience is essential. Please reply in confidence giving fullest particulars of experience and responsibilities, and salary required. File No. 6843-V.

CONSTRUCTION ENGINEER required for Buildings & Grounds Department of a Maritime University. Qualifications of candidate should be: Graduate civil or mechanical engineer; minimum of two years' experience; background preferably in construction supervision of buildings and underground services. Some design experience would be helpful. File No. 6849-V.

ELECTRICAL

YOUR OPPORTUNITY IS EXCELLENT for a future in a new modern Montreal area plant of a large American manufacturer. Electrical engineer desired with experience in the design of armature, stator and field coils to coordinate engineering and shop practices in their manufacture and in rewinding motors and generators. Initial training period at headquarters in U.S.A. Salary is commensurate with experience and ability. All replies are confidential. File No. 6790-V.

ELECTRICAL DESIGNER with at least 5 years' experience in the consulting field specializing in light industrial and commercial work. Salary commensurate with qualifications. Location of work Toronto. Interviews can be arranged in Montreal. Write Paul C. Ellard & Associates, 669 Bayview Avenue, Toronto 17, Ontario. File No. 6845-V.

MECHANICAL

MECHANICAL ENGINEER desired for design and performance calculation of steam generating equipment in engineering department of firm located in central Ontario, applicants should have two to five years' experience in above field, and University or Technical education. Alternatively applications will be considered of personnel having similar length of experience in estimating steam generating equipment. File No. 6836-V

MECHANICAL ENGINEER. Long established well known manufacturing concern located in the Maritime Provinces requires a graduate mechanical engineer in age range 21 to 28. Applicant should have a special interest in all phases of manufacturing a wide range of products. File No. 6844-V.

MISCELLANEOUS

PRODUCT ENGINEER requested by Montreal manufacturer to take charge of product design, with a view to setting up design department. Experience in design of heating and air conditioning units, household appliances or similar items involving sheet metals preferable. All inquiries confidential. File No. 6803-V.

GRADUATE ENGINEERS, Civil, Mechanical, Electrical required by leading consulting engineering office in Montreal. Civil engineers with experience in structural steel, reinforced concrete and construction engineering. Knowledge of prestressed concrete design preferred. Mechanical engineers for heating, ventilation and refrigeration. Experience in field and consulting engineering office preferred. Electrical engineers with experience in power generating plants, transmission lines and industrial installations. Permanent positions with good starting salaries, wide range of employee benefits and opportunities for advancement. Write, outlining your qualifications and experience to File No. 6813-V.

ALL AROUND ENGINEER for a long established growing plant in the Eastern Townships of Quebec. The job carries the opportunity of taking charge of all mechanical, heating, construction, refrigerator, electrical, automotive, materials handling matters using a trained staff. Emphasis on organizing, planning. Engineer should enjoy contract with men and operations. Permanent position, good salary. File No. 6817-V.

MECHANICAL-ELECTRICAL ENGINEER required by Quebec City consulting firm. Applicant should have a minimum of three years' experience in the design and layout of heating, ventilating, plumbing and electrical systems for large public buildings, and should be fully qualified to take charge of this department. Applicants should send resume of education, experience and salary requirements. File No. 6827-V.

ASSISTANT INSTRUMENT ENGINEER. Required by Pulp and Paper mill Eastern Ontario. Should be graduate chemical, electrical or mechanical engineer with one to three years experience in instrumentation or pulp and paper manufacture. Salary dependent on qualifications and experience. File No. 6835-V.

PHYSICAL METALLURGIST required for materials engineering section of major metallurgical and chemical plant in Western Canada. Work will entail advising on application of metals in process equipment, investigation of service failures and non-destructive testing. If interested write giving particulars of qualifications to: Supervisor, Staff Department, The Consolidated Mining and Smelting Company of Canada Limited, Trail, B.C. File No. 6838-V.

ENGINEER required well versed in agronomy or hydraulics, to sell water pumps and irrigation equipment. Must be prepared to travel abroad with probable headquarters in Belgian Congo and have fluent knowledge of French and English. American manufacture. Interviews arranged, Montreal or New York City. File No. 6841-V.

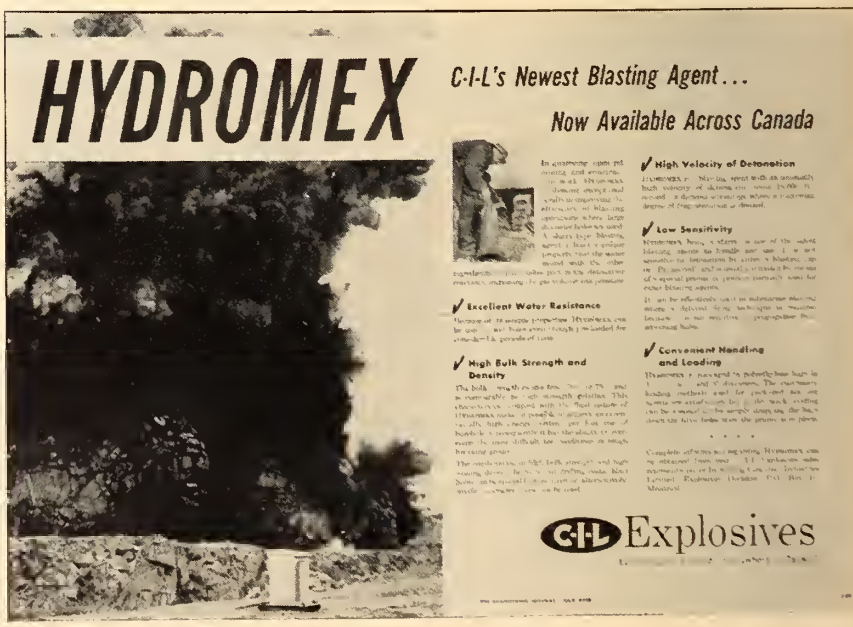
E.I.C. CERTIFICATE OF ADVERTISING MERIT

Canadian Industries Limited, Explosives Division, two page, two colour, advertisement has been selected as "the best" from the viewpoints of ACCURACY—INFORMATION—ATTRACTION, by a jury of fifty readers of *The Engineering Journal*.

The advertisement, which occupies pages 148 & 149 of the issue, is an announcement regarding "Hydromex", the Company's newest blasting agent. The copy outlines uses, qualities and conveniences of the product. This useful information is emphasized by a most dynamic presentation.

The names of the readers of *The Engineering Journal* who are asked to serve on the selection juries are taken from the general mailing list in such a manner that each Province is represented. A new jury serves each month. It is believed that by this means of selection it will be possible for the Institute to assist advertisers in preparing advertisements which give engineers the information they want in the way they want it.

The advertising supervisor for C.I.L., Explosives Division, is Mr. W. L. Hill. The advertising agency is Cockfield, Brown of Montreal, and Mr. B. Fuller is the account executive.



C-I-L'S CERTIFICATE WINNING ADVERTISEMENT

The Canadian Industries Limited, Explosives Division, two page, two colour, advertisement on pages 148 & 149, was judged "the best" in the July issue. The illustration on the left is a dynamic shot of a blast. It provides an excellent background for the word "Hydromex" which is printed in red. On the right hand page, the copy covers uses, properties, strength, density, velocity of detonation, sensitivity and conveniences of the product.

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

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November 1959
vol. 42 no. 11

Cables: Enginst-Montreal
PRINTED IN TORONTO

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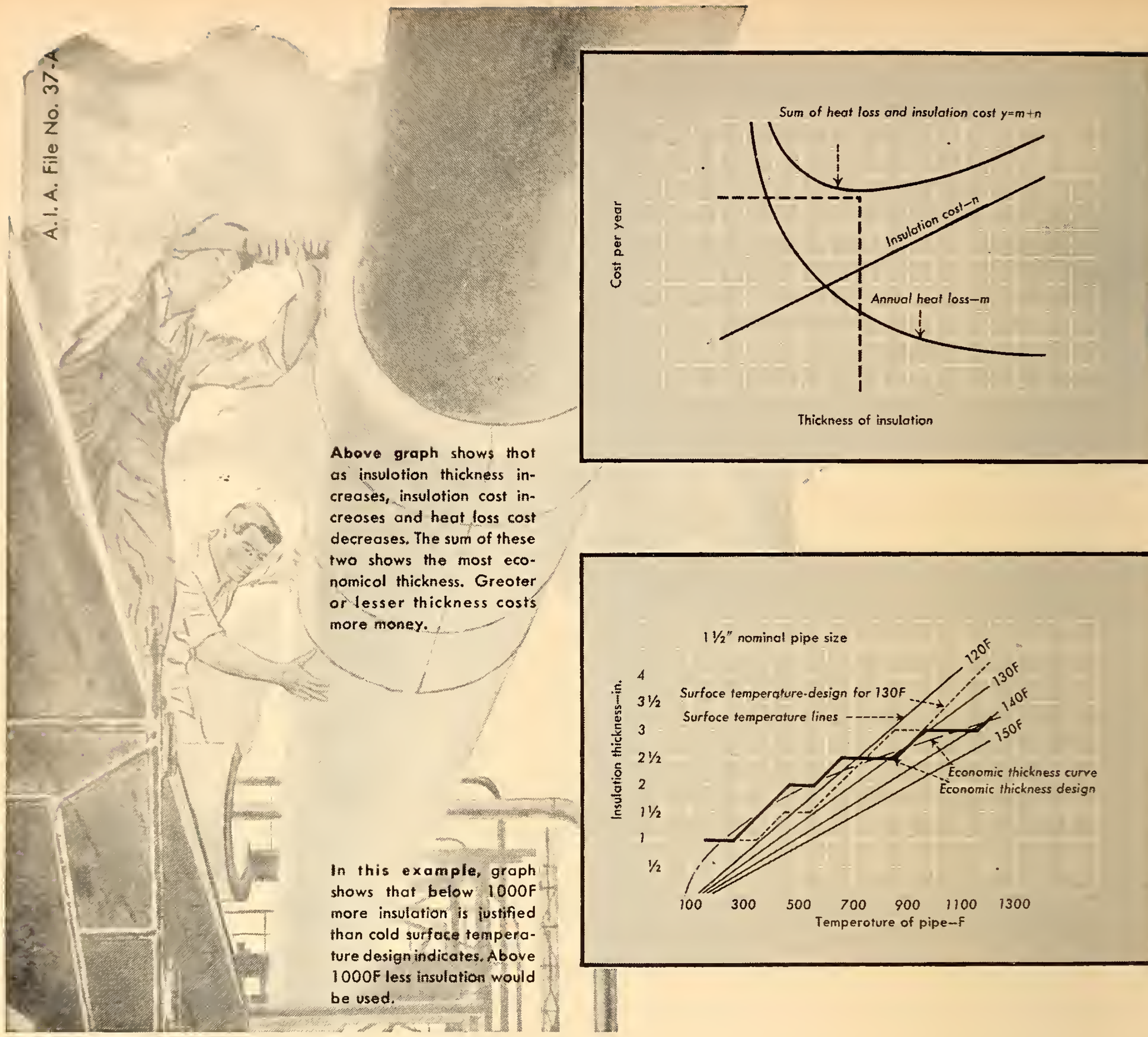

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To arrive at the above figures in a given instance requires the following: 1. Cost of heat production per million Btu; 2. Rate of heat loss through insulation in Btu per unit area per hr; 3. Annual hours of operation; 4. Applied cost of insulation per unit area; 5. Rate of amortization and required return on the insulation investment cost. Items 2 and 4 are available from the insulation manufacturer; others are normally supplied by the plant engineer.

For more complete information, call or write Dept. IA, Canadian Johns-Manville Co. Ltd., Port Credit, Ontario. Ask for reprint of technical article "Select Economic Insulation Thickness."

I-4034

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JOHNS-MANVILLE JM PRODUCTS

MEET THE AUTHORS

A. R. Morse, JR.E.I.C., assistant research officer, National Research Council of Canada (*Shock Hazards of Electric Currents*).

Mr. Morse served in Royal Canadian Signals 1940-1946. He is a graduate of University of Manitoba, electrical engineering, 1949. A large measure of his work at N.R.C. has been in investigating the cause of explosions of anaesthetic gases and of grain dust clouds in order to devise safety measures to prevent these explosions.

Gaynor P. Williams, research officer, Snow and Ice Section, Division of Building Research, National Research Council (*Frazil Ice—A Review of its Properties with Selected Bibliography*).

Mr. Williams graduated in 1949 with B.A.Sc. from the University of British Columbia and obtained an M.Sc. degree from Utah State Agricultural College in 1951. He worked with PFRA, Department of Agriculture as field engineer on irrigation and drainage problems in British Columbia until February 1952 when he joined the Aluminum Company of Canada as hydrology engineer at Arvida, Quebec. He joined the NRC in February 1955.

C. R. Crocker, M.E.I.C., Senior Research Officer, National Research Council, Ottawa (co-author of *Precast Concrete for Winter Building*).

Mr. Crocker graduated from the University of New Brunswick with degrees in electrical and civil engineering; worked with the New Brunswick Department of Highways and the Federal Department of Mines and Resources. In 1946 he joined the National Research Council and in 1950 went to Division of Building Research. He now heads the building practice, construction section.

A. W. Smith, Junior Research Officer, National Research Council, Ottawa (co-author of *Precast Concrete for Winter Building*).

Mr. Smith graduated from the University of New Zealand (B.E. Hons., 1955) and worked until 1957 as civil engineer for the Housing Division of the Ministry of Works, Wellington, New Zealand. He joined the National Research Council of Canada in 1957 and is working in the construction section of the Division of Building Research.

J. J. Traill, M.E.I.C., consulting hydraulic engineer (*Tests of Hydraulic Turbines—An Appraisal*).

Mr. Traill graduated in civil engineering from the University of Toronto in 1906 with a B.A.Sc. and C.E. Until 1920 he was on the staff of the University of Toronto as professor of mechanical engineering. From 1920 to 1954 he worked with the Hydraulic Department of The Hydro-Electric Power Commission of Ontario. Mr. Traill was special lecturer in fluid mechanics at the University of Toronto from 1954 to 1957.

R. J. Bedard, former editor of Genie Construction (*Business Training for Professional Engineers*).

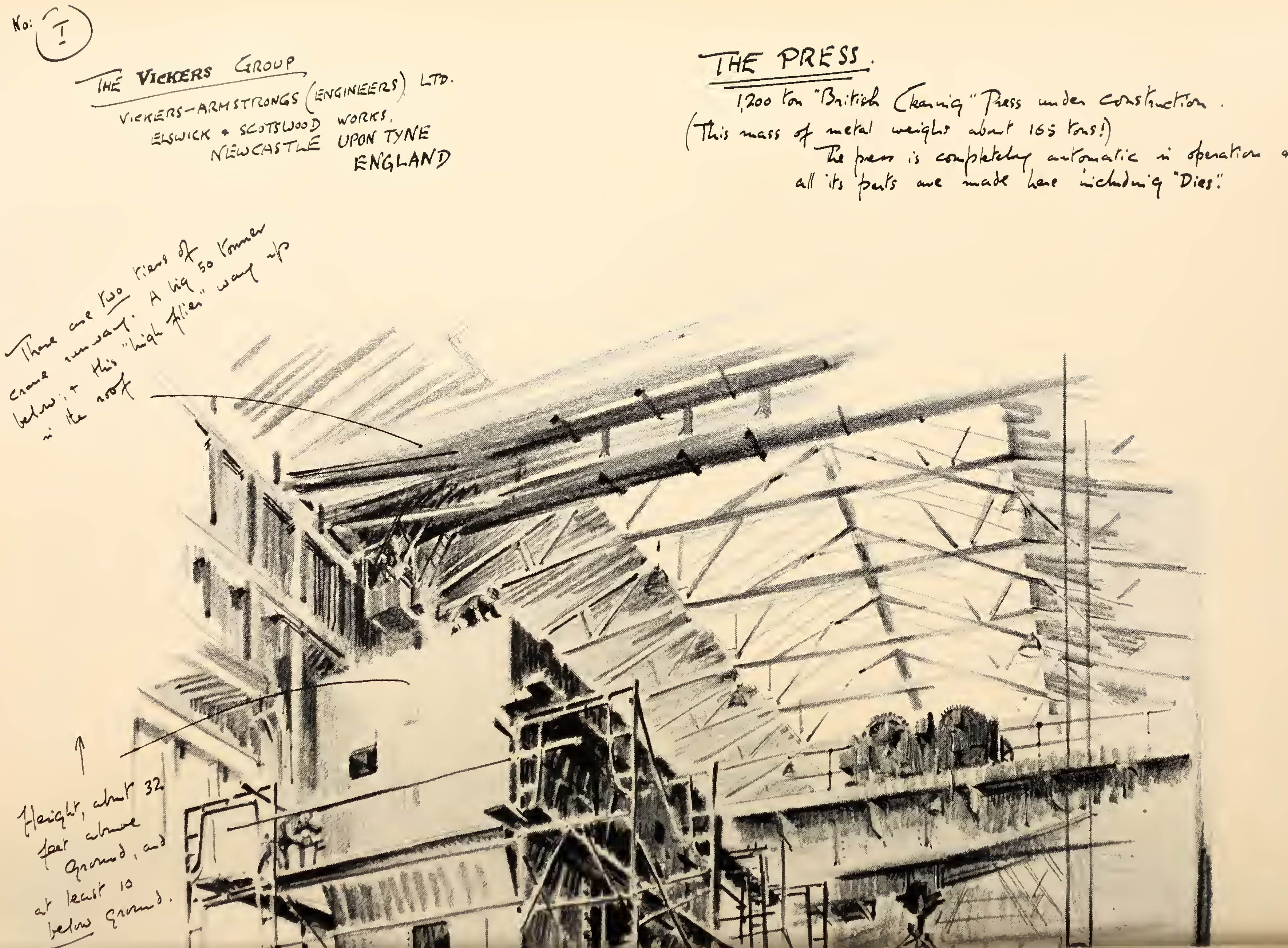
Mr. Bedard graduated from the University of Montreal and is at present attending the University of Geneva, Switzerland, working on research towards a Ph.D. He is the author of numerous contributions in Canadian and foreign technical journals.

P. R. Stratton, P.ENG., A.M.I.C.E., project superintendent, The Hydro Electric Power Commission of Ontario (co-author of *Silver Falls Generating Station* with C. T. Bath, B.E., P.ENG., A.M.I.E.(Aust.)). (Paper appeared in the October *Engineering Journal.*)

Mr. Stratton received his engineering education at London (England) Polytechnic and worked as articled engineer with the Essex Rivers Board. He later was employed as field engineer for Richard Costain Ltd. and as ganging engineer for the Great Ouse River Board. Since 1952 he has been with Ontario Hydro, serving as design, planning and construction engineer and as general superintendent.

Mr. Stratton is now construction engineer on Atomic Energy of Canada's CANDU project.

We are indebted to the Engineers at Canadair, Montreal, for their co-operation in the preparation of the paper on Materials Handling, appearing in this issue.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THE CHALLENGE OF ENGINEERING

From the Address of Dr. K. F. Tupper, Retiring President, at the Annual General Meeting, Toronto, June 8, 1959.

THE INTEGRITY OF AN ENGINEER is reflected in the soundness of his work, and there is a particular quality or attribute of engineering work about which I hold some views. This is the property of permanence, longevity, durability.

We engineers may—perhaps without knowing it—be responsible to a very large degree for how rich a world we live in and for how long hours most people have to work. That may seem a rather astonishing statement, so please hear more.

The rate at which we accumulate wealth depends on two simple factors—rate of production and life of article or work produced. I use the word wealth in its economic sense to denote the things which man has by his own efforts produced by working on materials which nature provides. Wealth includes buildings, bridges, roads, coal piles above ground, oil paintings, anything which man has devised.

I want to make now a simple analogy to get a point across. At one time I was concerned with the production of radio-isotopes. These are radioactive atoms, most commonly produced by bombarding an element with neutrons in a nuclear reactor. By putting a certain amount of target material in the reactor and operating the reactor steadily at full power, one can create a constant quantity of the desired radio-isotope each unit of time, say each hour. Unfortunately, however, if you want to produce 1,000 times as much as can be produced in an hour, it is not necessarily a good idea simply to let things run 1,000 hours.

The radio-active atoms are themselves disintegrating and this may take place at a fast rate or a slow rate. The usual way of referring to the rate is to speak of the "half life"—a time in which half of any large number of atoms of a given kind will have disintegrated. Suppose we were making an isotope with a half life of 24 hours. At the end of one hour we have a certain amount, and at the end of two hours nearly twice as much. But at the end of 24 hours we have a good deal less than 24 times the first hour's production. In fact, at the end of 24 hours we have lost nearly half of the radioactive atoms we produced in the first hour.

If we want exactly twice as much as exists at the end of the first day, we are really in a fix. In the second day we can produce as much as we did the first day but our first day's production has shrunk to exactly half its size, leaving us with ¾ of what we want. At the end of successive days we have, in fact, the following amounts:—

1/2: 3/4: 7/8: 15/16 —

and if we went on forever we would not quite reach our objective.

In case you want to know how one does get larger amounts, the answer is: use more target atoms, bombard with more neutrons.

Now in the world around us lots of things behave like radio-isotopes—they disappear for one reason or another. I often wonder what actually became of all the pocket knives I had as a boy. Some of them lasted a year, some lasted only a few weeks—even today I think the life expectation of my pocket knife (I still carry one) is only about five years.

I can think of certain roads which I will swear have been torn up and re-built every two or three years —or so it seems.

The house in which I live is about 30 years old. I am glad to say I think that as a whole it will last as long as I need it. As a whole, I said. The roof had to be re-shingled a few years ago. The garage behind the house has not done as well—it is scheduled for a complete re-build this year.

Now the number of pocket knives, garages, miles of road, etc., that we as human beings have at our disposal is determined by just these two factors—rate of production and length of life.

Engineers are today most intimately concerned with both factors. In their role as designers they determine to a very large extent how long many things are likely to last. In their role as producers, they help to determine how many units are produced each unit of time. I say help. Production requires the services of many people, the promoter who conceives the enterprise in the first instance, the financier who brings it into being, and so on to a whole host of people—with particular emphasis on the production workers themselves. In the matter of production the engineer is most certainly a member of a large team. The efforts of all are required in achieving increases in production.

I said earlier the engineer is probably very directly responsible for the amount of wealth we possess and the number of hours we work. These two are about linearly proportional—If we want to produce twice as much we have to work twice as many hours per week. Sometimes I am astonished that this fact is lost sight of. The dynamic prosperity of certain countries today—West Germany for example—is probably due more than anything to the willingness of the people to work long and to work hard.

There is today in North America a philosophy of expendability with which I do not agree—the idea of creating things which are intended not to last very long.

I submit that engineers can make a very real contribution—can easily do so—by seeking to make their work as durable, as long lasting, as circumstances warrant and will permit. They can leave behind them a world containing more wealth for their children and grandchildren to enjoy.

It is perhaps a matter of personal opinion, but I think an engineer lacks integrity if the quality of durability is deliberately skimped in his work.

The second quality is loyalty. Loyalty is a quality highly to be desired in an engineer—and here I have special reference to the employee engineer.

Loyalty between employer and employee is a two-way street. To begin with, loyalty must be deserved, it must be merited. The employer must treat his employees fairly—he must earn their loyalty. The employer must provide some things to be loyal to: standards of quality of product—of service—of honesty in business dealings. I can think of certain organizations—often dominated by one outstanding man—that earn tremendous loyalty in all their employees.

I submit that the engineer must be completely loyal to his employer. This may mean on occasions the implementation of policies with which he does not agree. The procedure to be followed in such cases is quite straightforward. When a course of action is charted with which the engineer is in serious disagreement he is ethically obliged to state his objections to his superiors. In many cases with a further exchange of ideas the engineer may alter his opinion, or, alternatively, the employer may modify the proposed course of action. If this agreement does not result then the engineer, having quite properly registered his objection, should adopt his employer's policy and administer it as though it were his own. It is indeed a form of disloyalty to implement a policy half heartedly or perhaps to give an order and then say "Of course this isn't my idea. I'm against it."

In the rare case where the divergence of viewpoint is diametric and where the matter is one of great importance, an engineer may find himself unable to carry out a course of action about which he has unsuccessfully protested. In this rare case I think he should quietly resign—without flame, smoke, or noise. He and his employer are apparently not compatible and it is better that the engineer should take the initiative in making the inevitable separation. Both self respect and the respect of all around him—including his employer—can thus be retained.

The third quality is what for want of a better term I shall call social usefulness. This means that the socially useful person performs a function of service to the society in which he lives. If our work each day leaves the world a better place in which to live we are performing socially useful work. Much engineering work falls very definitely into this category. The engineer who designs a bridge, manufactures a telephone or builds a municipal water treatment plant performs a pretty obviously socially useful task. Some of our engineering work gets over into areas not nearly so clearly defined as useful. I do not wish to try to identify any of these, partly for fear of giving offense and partly because some element of social usefulness can be discerned in almost any of them (I might think that a certain device—say a juke box—makes the world a less desirable, a less pleasant place in which to live. This, however, is a matter of personal taste and I feel sure my teenage daughter would sharply take issue with me).

I am sure we generally agree that the older professions—in particular Medicine, the Ministry and Teaching—have a social usefulness of a high order. Engineers are also the servants of their fellow men, and the engineers work can make the world a better place to live in. Let us strive to choose our work with this objective.

Finally, I come to a quality called humility—the act of feeling humble. If engineering is to be a profession, the individual engineer must be respected. I do not agree with the idea of trying to gain the respect of our fellow men through the efforts of a paid public relations expert. Respect must be earned and not bought. Consequently I do not subscribe to the doctrine that "Silent Service is Not Enough." I have yet to hear of an engineering job which was done better or quicker or more economically because the engineer tooted a horn to call attention to his work. This is not humility.

Would it not be better for us to concentrate our efforts on the kind and quality of our engineering, praying that we shall be sufficiently successful that our finished job will speak for us; that our own accomplishments will be our advertisements; that our own good engineering work will earn respect for our profession?

I find it a trifle incongruous that some of my engineering friends can find it possible to subscribe simultaneously to the Kipling Ritual and to the slogan "Silent Service is Not Enough." To me these are incompatible one with the other. To the humble engineer I think that "Silent Service" is quite enough.

This is the end of my homily. You may agree with some of my views, you may not agree with all of them. I will consider my message successfully communicated if it makes you think, if it starts some discussions.

MATERIALS HANDLING AT CANADAIR

Prepared in collaboration with Canadair Engineers.

THIS IS necessarily a limited treatment of the subject of materials handling at the manufacturing plants of Canadair Limited, in Montreal. The intention is to present a general outline of the main problems involved in the manufacture of aircraft, with particular reference to materials handling during the planning and assembly stages, and the way these problems are solved.

There is a wide field of operations, classifiable as materials handling, that are not covered here; among them the considerable activity in construction and maintenance involved in the daily work within a plant that has a covered floor area of some 2,600,000 square feet plus a very extensive outside area. Many trucks and other mobile equipment are involved in these operations.

Similarly, the economics of materials handling under the particular conditions of the aircraft manufacturing industry are more suitably dealt with as a separate subject.

What Are the Problems?

Materials handling in a plant that makes domestic appliances or automobiles, for example, is usually a complex, carefully-planned system involving various types of conveyors laid out for rapid and co-ordinated movement of many relatively small components through several stages to the final assembly line. Though periodic model changes affect the system to some extent, the general materials handling layout can often be maintained in its same basic form for considerable periods.

On the other hand, even a fairly small aircraft consists of many thousands of parts ranging from very small (screws, nuts, bolts) to very large (fuselage, wing sections), but the rate of final assembly may be only a few units a month. With many quite lengthy intermediate subassembly operations, great care must be taken in avoiding damage to large or easily-marred components, and the 'conventional' concept of an integrated conveyor system has virtually

Fig. 1 Model table showing layout for CL-44 fuselage assembly shop (upper right), final line (upper left), and preflight area (foreground). The floor is marked in the equivalent of two-foot squares. Note the relative sizes of the CL-44 and the small Sabre (at left).

Fig. 2 Mobile skin handling dolly. Note holes in wooden base for locating wooden positioning rods.

no place in the assembly procedure.

The main factor that precludes any more or less permanent materials handling layout is the vast difference in size of the aircraft that occurs from one contract to the next. For example, Canadair has produced T-33 jet trainers, F-86 Sabres, the CL-28, and the CL-44, the largest aircraft made in Canada. Some idea of the relative size of a Sabre and a CL-44 may be obtained from the illustration of part of an assembly area layout. The CL-28 will be used as an example of some of the procedures adopted.

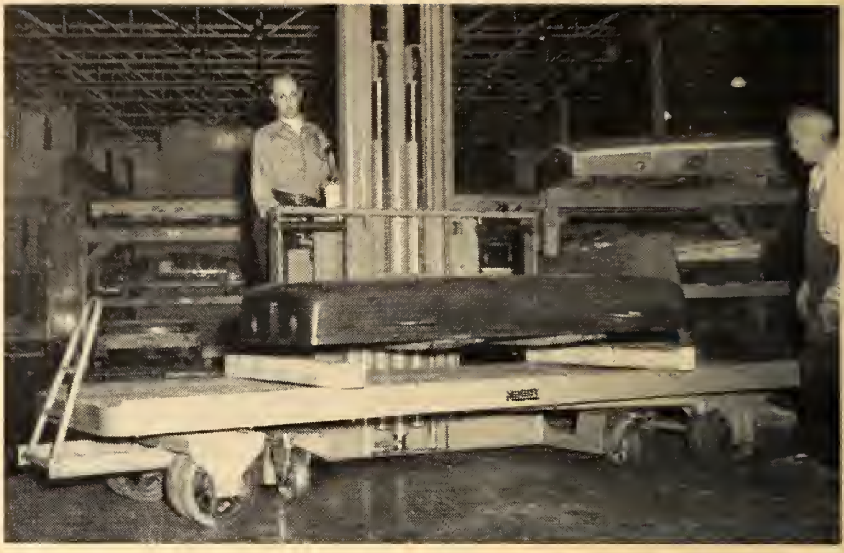


Fig. 3 Four-directional stacker placing a long fabricating tool on a trailer. The trailer has four-wheel steering for manoeuvrability around tight corners.

Planning for a Contract

When a new contract for a particular aircraft is to be undertaken at Canadair, the entire project is planned for the required production rate of that aircraft. Apart from necessary cost estimates, overall planning considers all pertinent factors of space, equipment and materials handling requirements.

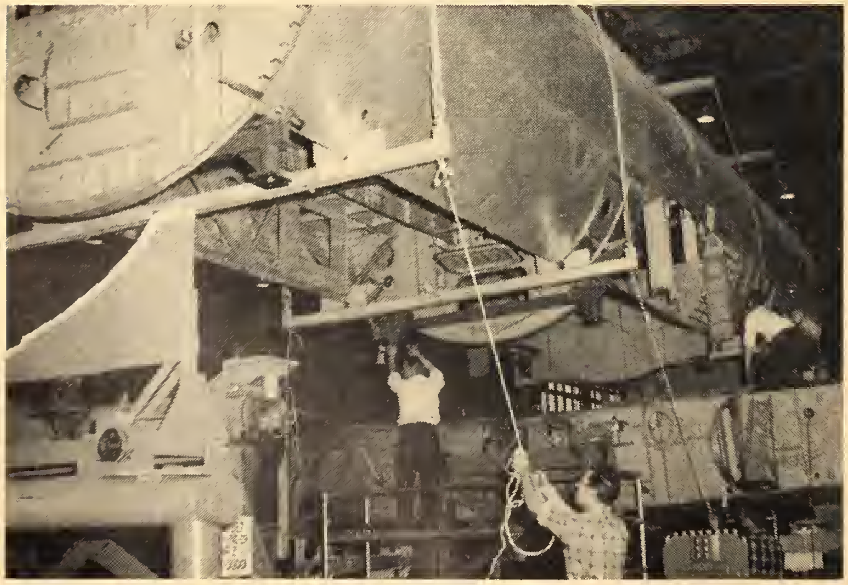
Plant Engineering, in co-operation with Industrial Engineering and Manufacturing Engineering, prepares a block plan of the manufacturing space to make best use of available facilities. At the same time, the flow of materials throughout the plant is planned to reduce backtracking and materials handling to a minimum. This is very important, since handling accounts for a major part of the time taken in aircraft assembly.

Plant Engineering keeps an up-to-date and very accurate record of floor space, known as the Plant Area Manual, which shows areas available or in productive use.

Each assembly department is laid out, in close co-operation with the Material Handling Group, on a three-dimensional master layout table. Using the international scale of ¼-inch to one foot, scale models of benches, equipment, etc. are positioned on the table, which is accurately marked with half-inch squares. A colour code is used for the models; for example, red denotes a component assembly jig, green indicates a machine tool, yellow is for furniture, and white shows racks and benches.

Most of the models are made from coloured plastic by a full-time model maker, with part-time assistance, in a fully-equipped model shop. Actual aircraft models are made from wood in the pattern shop. The models of jigs and fixtures are made with the help of tool drawings from the Manufacturing Engineering Department, and are complete in all essential details. The accuracy of dimensions is important because they are used to determine clearances in width, length, and height; details which are of concern to the materials handling group, as well as the production department.

Fig. 4 CL-28 centre fuselage being lowered into mating position.



General Flow of Materials

As already stated, the general flow of materials from raw stock to final assembly is planned to reduce handling. Raw stock is co-ordinated with the required tooling, and both are shipped from the warehouse to the detail fabrication shops. The existing warehouse buildings are as close as possible to the shops, but are actually separated from them by a main highway. Access between the two areas is by a connecting tunnel.

Detail parts are made in the shops from a variety of metals and plastics. Sheet materials are cut, formed, and drilled and many machined parts are produced. The detail parts are then joined together to make larger subassemblies, after going through various necessary intermediate operations, such as painting, plating, inspection and so on.

Handling of Detail Parts

Movement of raw stock from warehouse to fabricating shops and of detail parts from shop to finishing departments is largely made by means of wheeled dollies, hauled by *mule.*

Closely-finished machined parts are placed directly in special felt-lined compartmented boxes for handling between operations until plating, anodizing, and so on are completed, after which the parts are dipped in a rapid-hardening plastic material which forms a protective coating. The coated parts are then placed in boxes for hauling to the appropriate storage area in the assembly shops.

One of the few automatic conveying operations is found in the anti-oxidation treatment of certain alloy structural parts. The treatment consists of a sequence of dips and washes in a series of concrete tanks which are sunk in the floor. They are forty feet long, four feet wide, and eight feet deep, spaced two feet apart. The area is covered by a stabilized crane of two-ton capacity. When the racks have been loaded, the operator uses a push-button control to raise, traverse and lower the rack into the first tank, and thence in and out of the subsequent baths according to the predetermined time cycle. The paint shop has a standard plot bed and spray booths equipped with conveyors.

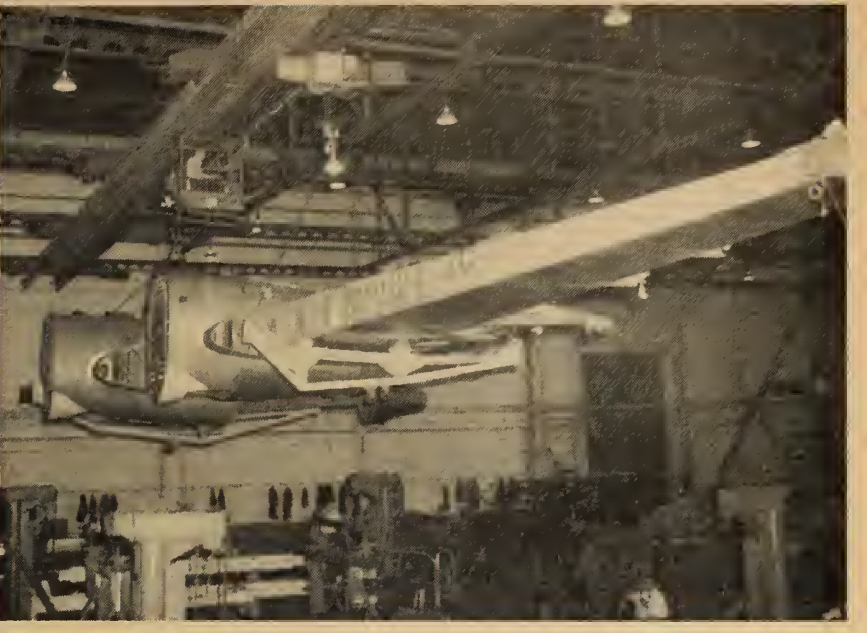


Fig. 5 CL-28 half-wing section being lowered by two-hook 6-ton crane into mating jig.

Handling of 'Problem' Parts

Some of the intermediate parts present particular problems in their handling, especially in the avoidance of damage to highly-finished surfaces or because of the size of the piece.

The skins, or formed metal sheets that make up the outer surfaces of fuselage and wings, may have a very fine (mirror) finish which has to be

Fig. 6 Vertical stabilizer mounted on its special handling fixture.

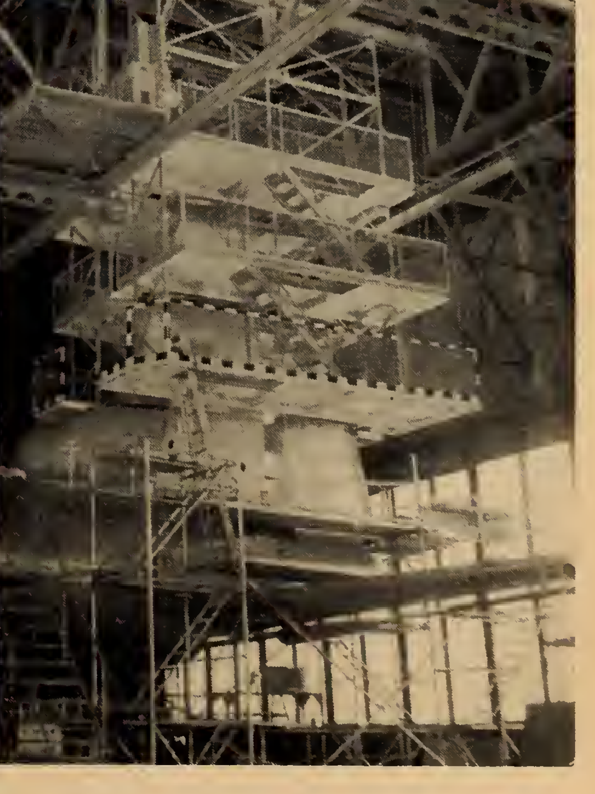


Fig. 7 Elaborate scaffolding used for access by men working on upper surfaces of tail unit.

unblemished when finally assembled into the aircraft. The handling problem is further complicated in cases of very large skins, which may run to some thirty feet long. For many operations the medium-size skins (say, up to 12 ft. long), especially those with a mirror finish, are moved manually and may be laid on a simple rack directly on the floor. (The expense of building special storage tables for these skins is not usually justified.)

Considerable work has been done on the handling of the large wing skins. One method used overhead grabs suspended from a tubular framework. The problem was to get sufficient pressure at the grabs to hold the skin securely without damaging the surface. A simpler variant of this idea was to leave an additional strip of metal beyond the final dimensions of the skin on which the grabs could grip. Damage to this part of the skin did not matter, as it was removed just before final assembly. Another method that has been successfully used it to leave small lugs of excess metal at intervals along the upper edge of the skin. These lugs are drilled to take a suspension pin, and are removed from the skin as late in the assembly operations as possible.

For skins of about eight feet and less, a special mobile skin handling dolly has been developed. These dollies, one of which is illustrated, consist of a rectangular steel base frame fitted with four caster wheels. Removable vertical steel posts are located at each of the four corners of the frame, and within these limits, any desired pattern of spacers may be made, using vertical wooden rods located in a series of holes drilled in a wooden base that runs along and across the main frame. The principle is shown in the illustration. For shallow skin sections, more than one layer may be stored by tying horizontal slats across the dolly uprights at the required height above the base.

This type of dolly is invaluable in the handling of the smaller skins, since it is used as a degreasing rack as well as a storage rack between operations and is also used to move the skins from one operation to the next. The flexibility of the design permits the ready handling of a wide range of skin sizes and shapes.

Another problem part is the wing spar, some 50 feet long in the case of the CL-28 main spar. Because of its length the spar is very flexible and has to be well supported during handling, which is largely done manually.

For moving long parts or tools, another specially-designed dolly is quite extensively used. This dolly has four-wheel steering actuated by the towbar so that it can turn readily around tight corners and in a restricted space.

Handling of Major Assemblies

The handling involved during final assembly obviously varies with the size of the aircraft. As a specific example of the methods used in assembly of a large aircraft, a brief description of the procedure for the CL-28 follows.

The major assemblies which go to make a large aircraft of this type are: (1) Forward fuselage. (2) Centre fuselage. (3) Rear fuselage. (4) Left hand wing. (5) Right hand wing. (6) Horizontal stabilizer. (7) Vertical stabilizer. (8) Rudder, control surfaces. (9) Engines and landing gear.

With the exception of the engines and landing gear, which will not be considered here, the eight main structural assemblies are constructed in special assembly jigs.

When completed structurally, the assemblies are removed from the jig to an installation dolly which secures the units without limiting accessibility, as would the assembly jig. At this stage the various internal fittings are added. After this installation procedure, the assemblies are transferred to the final mating jig, where, as the name implies, they are joined together to make the complete aircraft.

The main items are handled as follows, the dimensions being those for the CL-28.

Forward Fuselage — This unit weighs approximately 3,000 pounds, is 12 ft. in diameter and 20 ft. 2 in. long. After construction in the assembly jig, the unit is moved to its installation dolly by means of a 5-ton overhead crane. From installation dolly to the mating jig, the unit is again moved by the 5-ton crane.

Centre Fuselage — Unit weighs 10,200 pounds, is 12 ft. in diameter and 48 ft. 3 in. long. A specially-designed handling fixture is used to move the fuselage unit from the jig to subsequent operations. Part of the jig is used as a handling fixture, which runs on rails laid on the floor of the shop. The centre fuselage is held in its fixture until it is time for the installation procedure. The handling fixture is then moved out on an extension of the rail lines to a position that can be reached by a twin-hook 6-ton overhead crane, which runs over most of the length of the main shop, where the final assembly areas are located. The 6-ton crane transfers the fuselage unit from its holding fixture to an installation dolly. After installation work is completed, the fuselage unit is removed from the dolly and transferred to the mating jig by means of the twin-hook 6-ton crane with the assistance of the 5-ton overhead crane.

Fig. 8 Four-directional stacker with load preparing to move sideways down aisle. Note position of rotatable front wheel. Stacker can raise loads to a height of 15 feet.

Fig. 9 Hydraulically-operated 'giraffe' hoist is now used to move men working on upper surfaces of aircraft. Two of these units are in use at Canadair plant.

Fig. 10 Fork lift truck with swivelling head attachment about to dump contents of special waste-bin into garbage truck.

Rear Fuselage — Unit weighs over 3-tons, is 12 ft. in diameter and 41 ft. 10 in. long. The handling procedure is similar to that of the centre fuselage. However, the 5-ton overhead crane is used for the transfers from handling fixture to installation dolly and thence to the mating jig.

Half-Section Wing — Each half-section wing (left and right) weighs over 5-tons, is 71 ft. 2 in. long, and has a maximum width of 21 ft. 6 in. The wing sections are assembled in a box structure jig, and all handling from this point through normal operations to the mating jig is done by the twin-hook 6-ton crane.

The jigs, handling fixtures, and installation dollies mentioned above are designed and built to accommodate one specific unit. Though essential to the handling of that unit, the rate of actual handling may be very low. For example, in the case of a contract calling only for two aircraft a month, the handling fixture for centre or rear fuselage need only be moved from its holding position into the main shop twice a month. Certainly a far cry from the automobile assembly line.

The fuselage installation dollies are fitted with wheels, but are not used for actual movement of the unit from one location to another. However, the wheels allow flexibility in positioning the dolly during transfer of the assembly.

The handling fixture for the vertical stabilizer (see illustration) is of relatively simple welded steel frame construction and is mounted on caster wheels. In designing such a fixture, consideration must be given to the protection afforded the very costly assembly while keeping the overall dimensions within limits dictated by convenience of handling, clearances, and so on.

Other Aspects of Materials Handling

There are many examples of savings in time, labour, and cost that have been achieved at Canadair through improved methods of materials handling. Only a few such examples are mentioned below.

The 'Giraffe' — One type of materials handling equipment has been very usefully applied, not to the handling of materials, but to the handling of operating personnel. Two hydraulic '*giraffe*' lifts, of the type shown in an accompanying illustration, are used to move men rapidly and easily from one working area to another on these high surfaces.

Material Storage — Efficient use has been made of storage space with the aid of various types of materials handling vehicles. One particularly useful development is a four-directional stacker which can stack and remove palleted items to a height of 15 feet. The particular advantage of this stacker in handling items for storage is its mobility forward, backward and sideways. As may be seen by the accompanying illustration, the front wheels of the stacker can be swivelled 90 degrees from the forward or reverse travel position, so that the vehicle can be made to travel sideways from a standing start. This enables the stacker to move loads that are longer than the width of the access aisle between storage racks.

The stacker can pick up a load that is, say nine feet long; carry it in the usual forward direction where space permits; turn at the entrance to, say, a seven-foot aisle, and travel sideways up the aisle to the storage point, where the stacker raises the load and advances forward in the usual way to drop the load on to the storage rack. The procedure is reversed for removing long loads from storage.

This ability to increase cubic stor-

(Continued on page 60)

SHOCK HAZARDS OF ELECTRIC CURRENTS

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

SOME TIME AGO a query came to NRC regarding the possible change in Canadian death statistics if household circuits were increased to 240 volts to ground instead of the 120 volts to ground now commonly used. The question sufficiently fascinated me that not only did I read many papers on the subject of electric shock, but also I did a little experimenting. From that point, it was a simple step to consider that this subject would be at least of *some* interest to others as well as myself, and that I could save these others the necessity of reading, interpreting and experimenting.

One thing I would like to emphasize, is that I do not intend to discuss the changeover from two prong plugs to three-prong plugs as now being adopted in many parts of Canada. I can only say that having on one occasion fallen victim to the situation of someone "adapting" a three-prong plug to the old two hole outlet, I earnestly endorse a rapid and complete changeover to the three-prong, grounded-chassis 120-volt system.

We are concerning ourselves here primarily with the inter-related factors of the physiological and the electrical. By way of a little background, the many scientific workers investigating electric shock have found that the main factors affecting electric shock are:

A. **Electrical**
Duration of Current
Frequency of Current
Waveshape of Current
Magnitude of Current
Voltage Applied Initially

B. **Physiological**
General Physical Condition of Victim e.g. "Weak Heart"
Body Resistance
Skin Resistance
Contact Resistance
Path of Current-Effect
Phase of Heart Cycle Subject to Shock

Naturally with some factors there is no sharp dividing line between electrical and physiological.

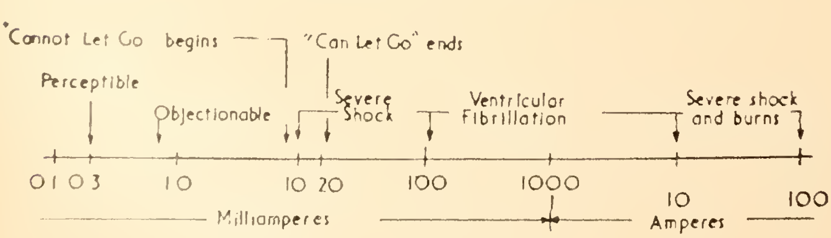
Early investigators were quick to recognize that there were roughly five main effects on the body:

1. Paralytic Injury to the Brain.
2. Injury to the heart as shown by loss of rhythmic heart beat—and hence circulatory failure.
3. Damage to tissue and organs by severe burns.
4. Respiratory failure.
5. Muscular convulsions.

Again there is no complete independence. For example, it was work by Urquhart in 1927 that showed that passage of current through the brain could cause respiratory paralysis and failure of the heart and blood vessels. He demonstrated also—and this is of great importance today—that the usual tests for death were not reliable when a victim has suffered an electric shock of this nature. Hence it is the firmly recommended practice to persist in artificial respiration until success is achieved and the victim revives, or until rigor mortis sets in. Not only is it necessary to be persistent in attempting artificial respiration but also it is important to begin it as soon as possible. This greatly increases the chance of the victim's survival for, owing to the interdependence of the body organs on one another it has been found that the combination of respiratory and circulatory failure rapidly causes brain failure from lack of oxygen, which is of course brought to the brain by the blood after being absorbed in the lungs. Hence one should not lose time or wait for pulmotors. This is the reason for the development of pole-top methods of resuscitation. Naturally, the first duty is to remove, in a safe manner, the victim from the electrical contacts, or to kill the circuit.

Another example of the mutual reactions occurring during electric shock is the case of electric shock

Fig. 1 Effect of 60 cycle current on men.



therapy. Here again the passage of current is through the brain. Side reactions may involve violent muscular convulsions. As a final example, it is obvious that both respiratory and heart failures involve the related muscles.

It was Ferris, King, Spence and Williams who in 1936 concluded from tests on animals with 60 cycle current that the effect of electric shock is related to the magnitude of the current, rather than the voltage, and also is related to the weight of the animal and of the animal's heart. They also discovered that fibrillation of the heart is most likely to occur at one particular point in the heart cycle. In 1939 Wiggers and Wegria also investigated the "vulnerable point" in the heart cycle, and concluded that a shock of duration less than 1/10 second could be fatal. Since 1900 there has been serious work on the reaction of the heart to electric shock. This work today includes the building of practical machines to stop heart fibrillation.

What are the values of 60-cycle currents through the body that give the normally recognized reactions? If we draw a logarithmic scale of current (Fig. 1) from 1/10 milliampere to 100 amperes, we can indicate the various ranges that will be under discussion:

"Perceptibility" depends on the location and size of contact and on the type of current. The value given is for finger contact; tongue contact is probably something less again, and a large area contact is almost an order of magnitude larger.

At the "Objectionable" level, some people find it hard to accept that 1 ma is objectionable, until they have tried it. Beginning with the next level of currents we once again tell the tale as determined by past investigators. This level is commonly known as the "Let-Go" Level. Above about 9 ma, we begin to find victims who cannot let go. And here we call on the work of Charles F. Dalziel and co-workers at the University of California. These workers, after investigating the nature of reported electrical accidents, felt that it was important to have data on the physiological effects of electric currents on humans where the humans grasped a copper wire or pair of pliers in one hand, while making the other contact elsewhere e.g. to the same arm, to the other hand or to the feet. Using the results of tests on over 100 men as a basis, they presented to the electrical profession the following definition of a "Let-Go" Current: —a let-go current is that which 99½% of the healthy adult male population can safely tolerate without loss of ability to voluntarily let go of the conductor which is held in the hand. Naturally any current less than the "Let-Go" Current also can be let go, and also, by definition, almost all adult males can release even more current than the Let-Go Current as defined. Hence there is a good "Margin of Safety." There have been no adverse remarks over the years on the Dalziel choice of what to consider a Let-Go value, and so we assume that this is the established criterion.

To make the definition more rigorous, one should describe in greater detail the electric circuit. A No. 6 copper wire was used as the active electrode. It was grasped by the hand. The other indifferent electrode was a large-area wet contact, usually on the upper part of the same arm, but in some cases on the opposite hand or a foot. These inactive electrode locations had little effect on the let go current. In the course of his experiments, Dalziel tested men who were able to let go currents of as high as 22 milliamperes. The average was about 16 milliamperes while the low was about 9 ma. When plotted on probability paper — percentage who can let go of total persons tested vs current in milliamperes— the experimental points fell quite well along a straight line, thus showing the Distribution to be Normal (Gaussion) See Fig. 2.

Tests with women gave similar results, although women can stand only about 2/3 the current that men can stand. Hence 7 ma forms the "Let-Go" value for women as compared to 9 ma for men.

The test results were also plotted as percent deviation from the mean. (Fig. 3)

Naturally the plot looks very similar to the Distribution plot, but by using percent deviation Dalziel's group discovered they could spare some of their reluctant 134 men from the time-consuming and nerve-racking tests. For now they found that 60-cycle tests on smaller groups of men all yielded deviation curves of the same slope. Therefore, for further different tests, in order to adjust results on small groups to agree with the large group they would run a 60-cycle test first. If the deviation curve agreed with their standard deviation curve, then even though the distribution curve might be different—for example have a different mean value—the new test would be accepted as valid for a large number. It was however subject to adjustment in proportion as the large-number standard 60-cycle test mean differed from the test standard. That is, for example: corrected mean of new test =

$$\frac{\text{mean of Large Standard (15.87 ma)}}{\text{mean of Small Standard}} \times \text{experimental mean of new test.}$$

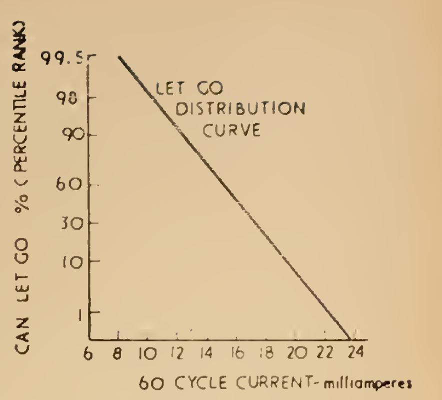


Fig. 2 Percentage of total persons tested who can "let go" vs current in milliamperes.

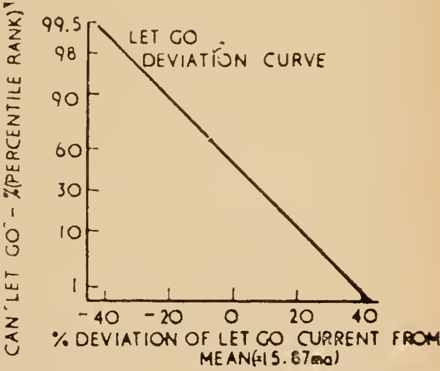
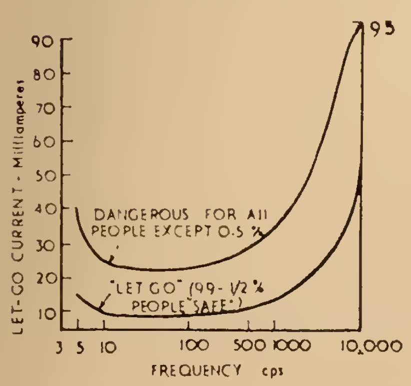


Fig. 3 Test results plotted as percent deviation from the mean.

Fig. 4



Work then progressed more rapidly for Dalziel and his confreres. The University of California group have to date published many papers on Let-Go currents, and even Let-Go voltage, under various circumstances. They have confirmed the results of earlier workers that the 60-cycle wave is just about as obnoxious a wave as you can get. See Fig. 4.

Response is rather flat from 10 cps to 1000 cps, increasing about fivefold for dc and for 10,000 cps. The explanation for this evidently lies in the realm of medical physics—in the study of the response of muscle and nerve cells to electric impulse and current. We have a somewhat similar phenomenon with the heart where fibrillation occurs at one particular point of the heart-beat, and is particularly dependent not only on the magnitude of the current but also on the frequency. Incidentally, Dalziel reported that his deviation curves for 10,000 cps tests were appreciably different from his Standard. Physiologically, things didn't feel so bad—you felt that you were being pleasantly cooked to death rather than violently shaken to death, and your ability to let go was slowed down.

With direct current the "Let-Go" is actually based on fear rather than inability to operate one's muscles. For the interruption of direct current produces a violent shock, and sooner or later one feels that one would rather cook than stand that.

This violent shock on interruption of d-c is actually a forerunner to the results obtained when using waveforms of various shapes, for it is found that the peak of the current wave actually governs the physiological effects. When there is a mixture of d-c to a-c, such as occurs with some welding machines (e.g. 6% a-c), a composite Let-Go Curve can be obtained. (Fig.5) We see that a small a-c component reduces the average Let-Go Current appreciably. For example a 6% a-c component allows only 28 ma d-c as compared with 65 ma for pure d-c.

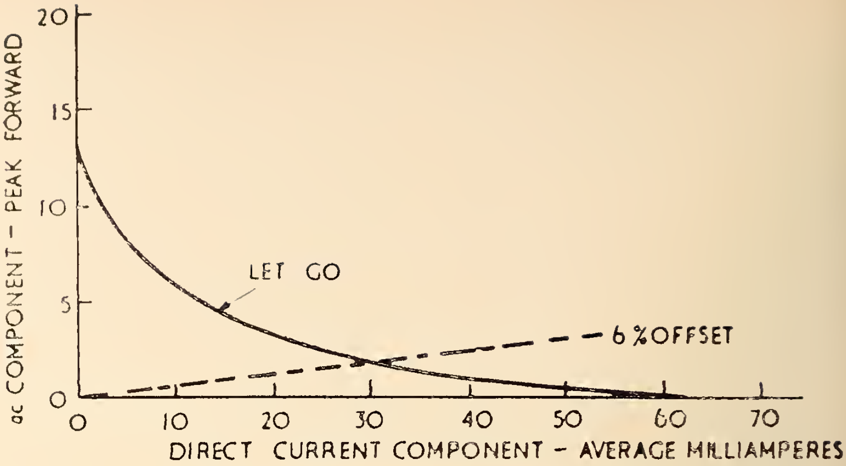


Fig. 5 Composite let-go curve.

The ac crest component shown is that peak of a-c greater than the d-c in the forward direction. See Fig. 6.

We should now correct any lingering impression that the Let-Go value of 9 ma applies to *all* 60 cycle waves. The best way, perhaps, is to state that for a 60 cycle wave, the *crest* value of current tolerable is 13 milliamperes. For waves having a dc component the composite curve must be used.

Before leaving a consideration of Let-Go currents, it would be well to recall that it had been found by Ferris et al that effects were more or less in inverse proportion to the weights of the animal and of the heart. Based on this, and also on their own experimental work, Dalziel and co-workers have stated that children can stand about one-half the current that man can stand; women can stand about 2/3 the current.

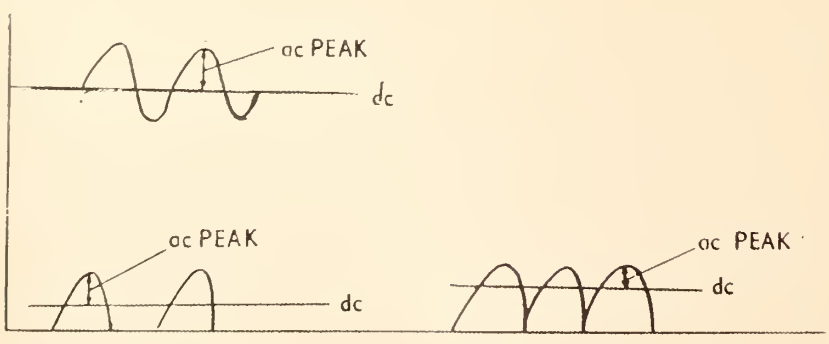
This fact is also useful in determining the *higher* ranges of currents, for tests on animals can be made and the results extended with reasonable accuracy to humans. This has been done, and O. Schneider neatly summarizes the situation. In his preliminary discussion, Schneider distinguishes between (1) the heat effects leading to combustion of tissues and organs and poisoning by combustion products, and (2) the electro-physical effects *proper*, which mainly affect the heart and circulation and presumably the nerves, muscles and brain and hence the respiration.

Now up to 25 ma a-c, the currents cause muscular cramp. It has been stated by several authors that prolonged contact to currents of over 20 ma, and even of over 10 ma where one cannot let go, may lead to a state of exhaustion, loss of consciousness and inability to breathe. The muscular convulsions will cease when the current is removed, but the *inability to breathe may persist*, requiring artificial respiration.

From 25 ma to 80 ma this situation is definitely intensified, and, particularly since it is very doubtful if one can let go, death is very possible.

From 80 ma to 8 amperes, Schneider states that death is instantaneous, due of course to ventricular fibrillation. Naturally, in all the above it is presumed that the current traverses the body, particularly via a hand grasp. While this is not always the case, it is often enough the case to be given major consideration. Also, the heart itself does not require 80 ma to cause fibrillation. Probably less than 1 ma passes through the heart.

Fig. 6 The a-c crest component shown is that peak of a-c greater than the d-c in the forward direction.



Nevertheless, tests on animals have shown that good statistical accuracy is obtained by discussing the total current. Another factor in fibrillation is again duration of contact, but anything over 1/100 second may be fatal. To some extent, the longer the contact the lower the current required for fibrillation. Several authors give from 100 ma to 10 amperes 60 cycle a-c as the fibrillation range.

You probably have noted that I have not tried to define fibrillation of the heart. This might perhaps be more confidently undertaken by someone from the National Research Council Instrument Section, where heart defibrillators have been designed. Suffice to say that the heart loses its rhythm, muscles quiver in an unco-ordinated manner even after the current is stopped, and the heart cannot regain rhythm. Hence the victim is sure to die. Artificial respiration does nothing to restore the heart rhythm.

However, when the current exceeds 10 amperes the heart does not fibrillate but seizes. Cessation of current permits the heart to regain rhythm. This may occur automatically, or of course it can be done by an operation if time permits. No doubt the reader is sufficiently familiar from the newspapers with high voltage accidents of this type. And of course, if a heart is already fibrillating, a large dose of current (of the order of amperes) through the heart for a short time can be used to stop fibrillation.

If the body is subjected to large currents of 10 amperes or more, the fact that fibrillation is not present does not guarantee long survival of the victim. We now enter the range of combustion. The victim is subjected to severe burning of tissues and organs and poisoning by combustion products, plus possible hemorrhage and severe shock. Death is probable, though perhaps not immediate. Resuscitation is often successful, if immediately applied.

The current that the body is subjected to is dependent on the voltage applied and on the total resistance between contact points. An "Ohm's Law" Log-Log "Sensation Chart" (Fig. 7) can be drawn that is very useful for showing the ranges of currents under consideration, and the corresponding voltage and resistance values.

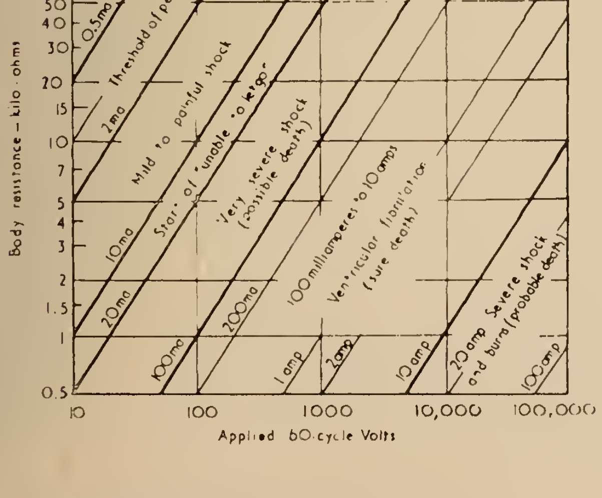
The ranges as they apply to a normal man subjected to 60 cycle sine wave have been shown. At the lower end some overlapping occurs because of the effects of different areas of contact. The smaller the area, the more sensitive the subject is to the currents.

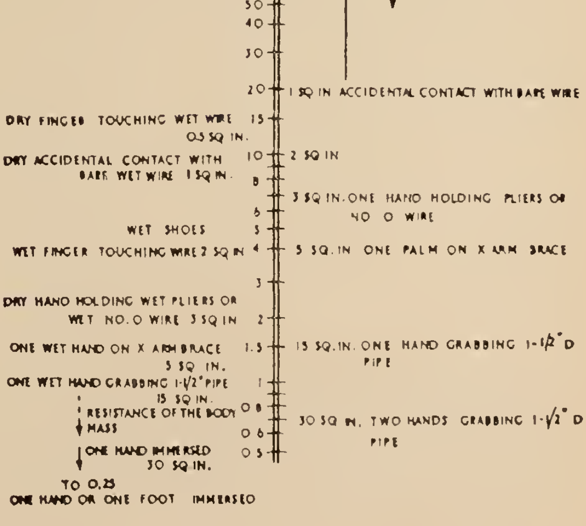
The "total body resistance" between contacts can be divided into three parts. One part is the contact resistance and may be quite low, or it may offer an appreciable impedance. For example, we may consider shoes as an item of contact resistance, as compared to just the interface resistance say between a bare wire and the skin. Another part is the actual resistance of the body itself, discounting the skin. This resistance lies between 500 and 1000 ohms for almost all dangerous body paths, for example from hand to feet. It is very unlikely that it is less than a total of 500 ohms, although from the chest to the back it has been said to be as low as 100 ohms. Also, to some extent it is dependent on the location and area of entry to the current. Kouwenhoven, who has conducted many defibrillating experiments, gives a value of about 100 ohms per cubic centimetre.

The third part of the Total Body Resistance is provided by the skin. It is very fortunate that so very often the skin resistance is high, especially on the back of the hands if exposed to the air. However it is very unfortunate that skin resistance is very sensitive to a variety of conditions and cannot be depended upon. It would be well to discuss this skin resistance a little more fully, for it would be very useful to determine the distribution of frequency of occurrence of total contact-to-contact

Fig. 7 below: 60-cycle electric shock hazard to adult males.

Fig. 8 right: Body contact resistance. →





body resistance under conditions of accidental contact, and the skin is the large controlling factor. From such information one could evaluate the *percent chance* of any particular current flowing in a human being who accidentally exposed himself to some given voltage. For example, we see from the Sensation Chart that for 100 volts an adult must present a resistance of less than 1000 ohms in order to be in danger of fibrillating currents, and for 200 volts the resistance is 2000 ohms. If we knew statistically that the percentage of people presenting 1000 ohms or less is almost identical to the percentage of people presenting 2000 ohms or less, then we might feel, from the point of view of safety against fibrillation, that house circuits for example could be 200 volts to ground instead of the present 110 volts without upsetting Canadian death statistics. Such a situation could occur if, for example, the "frequency of occurrence" curve turned out to be Gaussian along the resistance scale of the Sensation Chart, being practically flat and very low for resistance less than 2500 ohms, and being a maximum at some higher value before falling off again at still higher values.

An article by H. H. Watson in the February, 1959 issue of *Electrical Engineering* reviews a Symposium, held at the AIEE Winter General Meeting in New York in February, 1958, to discuss safety considerations if residential voltages are raised from the present 120-volts-to-ground to 240-volts-to-ground. It is apparent from this article that very serious consideration is being given to raising residential voltage, so the question we have posed is not an academic one. Mr. Watson offers the conclusion that the use of potentials twice as high as the present 120/240 volt level will increase the hazards already present in the existing levels but not in numerical ratio to the increase in voltage. However, I believe his conclusion is not based on the sample situation just given. Rather it is based on tighter safety design measures, limited use of the higher voltage, and probably also on the fact that he is not considering solely shock or death hazards, but also for example, fire hazards.

A start was made at the National Research Council of Canada on measuring the total resistance a body presents to 60 cycle voltages under different conditions of contact, the conditions being designed to duplicate at least to a degree the type of accidental contacts people do make. Unfortunately, this work was interrupted, but results obtained were felt to be of some value, and were given during discussion of a paper by Kouwenhoven et al in New York in 1957. Fig. 8 summarizes the results and covers the same range as the Sensation Chart, for easy comparison. Dry contact conditions are on the right side of the scale, wet contact conditions are on the left side. Values given are, unless otherwise stated, for the resistance of the single contact shown. Total resistance is dependent on the nature of the second contact plus the body resistance which is given as approximately 800 ohms. It was found that resistance during accidental "line contact" (i.e. over say a length of 2 in.) on dry skin is very dependent on the condition of the skin. For instance the back of the hand, while apparently having much thinner skin than the palm, is often very dry and is somewhat hairy and can give very high resistances. Other parts of the body, for example the neck, are not usually as dry. High voltages may cause puncturing of the skin, e.g. through a sweat pore on the back of the hand. Hence at high voltage the resistance may be more likely to change to a final value of below 5000 ohms. Values for wet hands or feet, grabbing or immersed, may go even as low as 250 ohms.

We also determined that the pressure of contact played a very important role in resistance. Presumably this is because of increased effective area of contact and probably also because of a more rapid creation of sweaty contact. For the data shown on the Body Resistance Chart, "reasonable" pressures were used.

The high values shown in the Body Resistance Chart under "dry" conditions should not be interpreted to give anyone a sense of security! This caution is made because it was found that a very small break in the skin could cause a very large change in resistance, for of course it is the skin resistance that accounts for pretty well all body resistance after the first 500 to 1000 ohms.

While we have not achieved our final objective of developing a statistical curve of "frequency of occurrence" against "resistance," an opinion may be offered on the shock hazard of increasing residential voltage. If we consider a reasonable lower limit of total body resistance in most cases of electric shock from residential voltage (120 volts) to be about 1000 ohms, we see from the Sensation Chart that the possibility of Ventricular Fibrillation is very slight. If most accidents occur with resistances above 1000 ohms the victims, while they may suffer severe shock, stand a good chance of survival, particularly as artificial respiration can be effective. Now, if the residential voltage is increased to 240 volts the possibility of Ventricular Fibrillation for the low resistance accident is increased considerably. For 5000-ohm medium resistance accidents (fairly likely—see the Body Resistance Chart) the severity of the shock is doubled by doubling the residential voltage, and as this is a range of "probable death" it is probably safe to say the number of this class of fatalities would be doubled. H. H. Watson further states: "Potentials of 240 volts to ground should be used only for permanently wired fixed appliances." In fact, considering that for children one must halve the shock currents shown on the Sensation Chart, and considering the limited advantages obtained if H. H. Watson's conclusions are adhered to, the present practice of 120/240 residential distribution is probably hazardous enough.

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FRAZIL ICE

A Review of its Properties, With a Selected Bibliography

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This report reviews the theory of frazil ice formation and the main factors which cause formations. The methods of forecasting frazil ice and the design and remedial considerations are also included. Although the frazil ice problem has been solved at many sites in Canada, this review summarizes investigations which would not generally be available to Canadian engineers.

WHENEVER supercooled water in reservoirs, lakes or rivers comes in contact with hydro-electric plant intakes, water supply intakes, irrigation and water supply canals, there is a danger of serious clogging because of frazil ice. Frazil ice occurring in large rivers is a navigational hazard and can be the cause of serious ice jams. In Canada the work of Barnes[1] is the first major effort to present detailed summaries of available information on frazil ice formation and occurrence. Since then many investigations have been carried out, notably in Russia and other European countries. As no publication is available in English, apparently, which summarizes these more recent developments, this survey of existing information on frazil ice has been prepared, accompanied by a number of selected references.

Theory of Formation

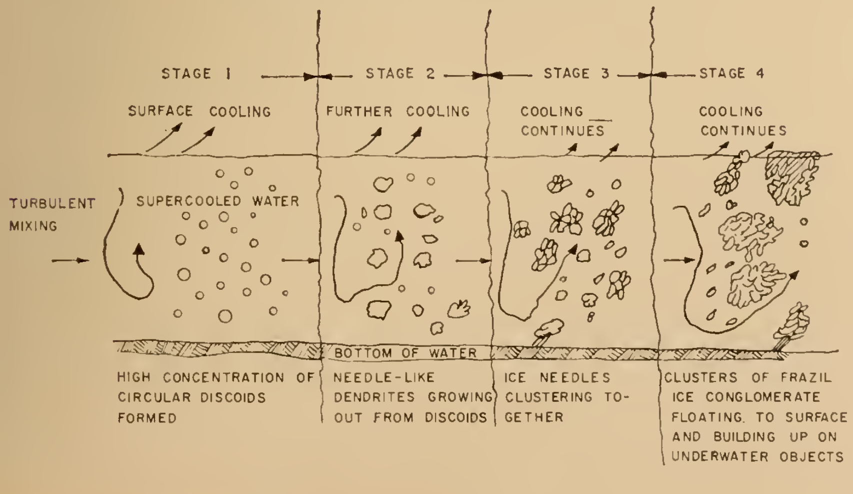
Ice is formed on the calm water of small lakes and stagnant pools when the loss of heat to the atmosphere by radiation, convection and evaporation results in the supercooling of the surface water. In this static type of ice formation described by Devik[2] the crystallization begins partly from solid matter on the beach and from solid material suspended or floating in the water. If the water remains at rest and the cooling continues, a surface sheet of ice is rapidly formed.

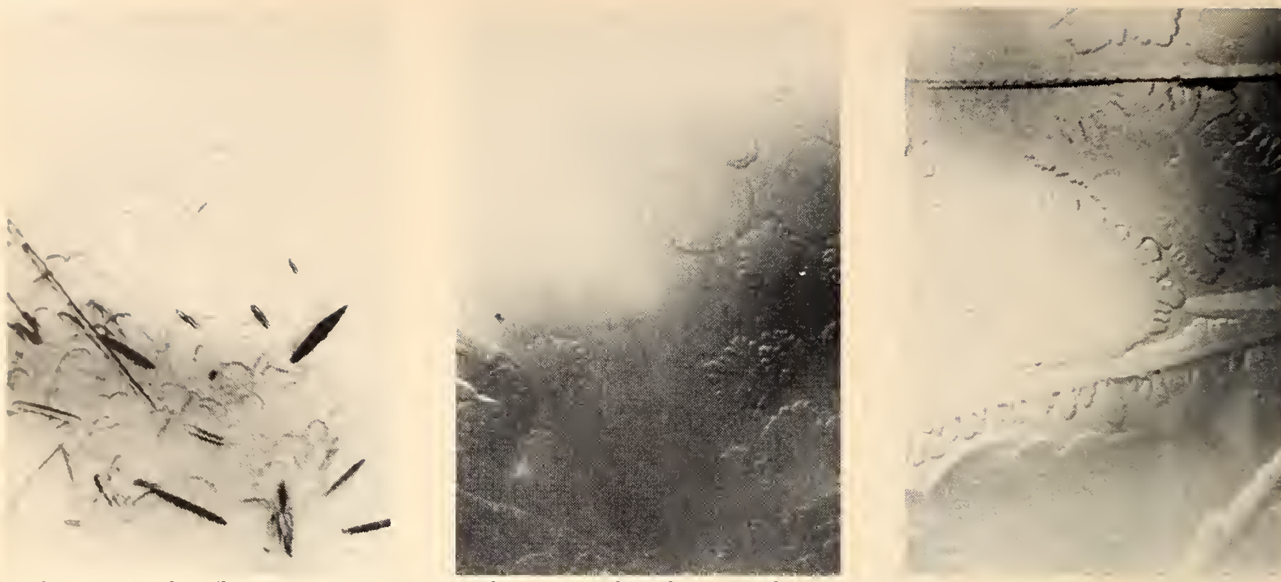
With dynamic ice formation as in running water or on the surface of lake water disturbed by wind, surface water exposed to the heat loss will be interchanged with water from lower depths so that a mass of water down to different depths, depending on the degree of turbulence, will be cooled to 0°C without ice formation. If the cooling continues the water near the surface will be supercooled a few hundredths of a degree (Altberg[3]). At a certain stage in this supercooling, frazil ice particles will start to form.

In their early development, frazil ice particles are thin circular discs. Frequently, the particles are of irregular outline but the edges are invariably rounded as shown in the excellent photographs by Schaefer[4]. As growth proceeds, however, flat dendrites grow out from the edge of the flat discs, eventually producing the needle-like fragments commonly recognized as frazil ice. Under favourable cooling conditions these fragments rapidly form and group into the large spongy masses that cause so much trouble on underwater installations. Figure 1 illustrates the different stages in frazil ice formation. Figure 2 shows some micro photographs of frazil ice in different stages of growth.

A similar type of formation occurs in lake water when supercooling coinciding with strong wave-action results in agglomeration (Wilson[5]). Even though the general nature of frazil ice formation has been known for a long time there is still argument and confusion in the literature

Fig. 1 Stages in frazil ice formation.





Frazil ice particles floating on water surface.

Frazil ice particles changing shape at water surface.

Frazil ice particles growing and changing pattern at water surface.

Fig. 2 Micro photographs of frazil ice in different stages of growth.

regarding the phenomenon (Timonoff[6], Lambor[7]).

Supercooling and Nucleation. Investigators seem to agree that supercooled water often exists in streams for long periods — even for days under favourable conditions[8]. There is argument, however, regarding the amount of supercooling, although it is generally assumed that it will rarely exceed .01°C in natural streams and lakes (Schaefer[4]). The theory of supercooling is still a matter of some disagreement. Dorsey[9] indicates that there are two theories to explain the freezing of water and the phenomenon of supercooling. In one, freezing is considered to be initiated by certain aggregates of water molecules called ice molecules. The other theory considers freezing to begin as heterogeneous singularities, i.e., foreign particles in the water which serve as nuclei. Dorsey combines elements of both theories. He distinguishes between an embryo comprised of water molecules only, and a complex embryo with a foreign particle as a centre to which molecules of water adhere.

Altberg[3] believes that crystals do not form in absolutely pure liquid but only upon dust particles suspended in the liquid. He concludes that the ability of a liquid to crystallize depends upon the number of nucleating centres per unit volume. Piotrovich[10] in a more recent study, points out that in water with only a few hundredths of a degree of supercooling, all ordinary inclusions are inactive as crystallizing agents.

Kumai and Itagaki[12] in their cinematographic study of ice crystal formation in water conclude that the rate of growth of discoids (or frazil ice particles) is a function of the rate of cooling of the water and the number of discoids. Their photographs show clearly the development of circular discoids into stellar crystals. Their studies show that with supercooling from 0°C to —0.3°C, discoids and spicules are produced, and from —0.6°C to —0.9°C spicules only are produced.

Much of the work done in recent years on the physics of supercooled water droplets in the atmosphere is of relevant interest to investigators of frazil ice (Schaefer[13]).

Frazil Ice Properties. The frazil ice discoids vary in size. Schaefer[4] observes particles with a range of thickness 25 to 100 microns for particles 1000 to 5000 microns in diameter. Hubbard[14] reports thickness almost identical to those reported by Schaefer. Altberg[3] claims that discoids up to several centimetres in diameter could be grown artificially. Baylis and Gerstein[15] have observed particles that grow rapidly from ⅛-in. diameter up to 4 in. in diameter and 1/32 in. thick.

The buoyancy of frazil ice particles is of particular practical interest. When the stream flow is not extremely turbulent, frazil particles remain submerged and do not appear to collect at the surface. Barnes attempts to explain this phenomenon in terms of viscosity and Stoke's Law[8]. Schaefer[4] suggests that the large ratio of major to minor axis and the small difference in specific gravity between ice and water cause the particles to tumble about within the stream much the same as water-soaked leaves are carried underwater in a turbulent stream.

Schaefer[4] estimates that the volume concentration of frazil ice approaches 10^6 per cubic meter in his observations of frazil ice on the Mohawk river in 1950. Frazil ice particles will adhere to each other and also build up on underwater objects causing many problems. According to Piotrovich[10], when water is supercooled there is a strong increase in the cohesion forces between ice crystals and in the adhesion of ice crystals with stones, wood, metal and other objects in the water. Schaefer suggests that the laminar type of build-up indicates regelation between these ice particles.

Piotrovich also suggests that, as ice does not adhere strongly to certain substances as plastics of purely organic composition, these may be used as coatings to protect against underwater ice accumulations. According to Murphy[16] waterwheels protected by wooden racks are better able to withstand frazil attacks than those protected by iron racks, indicating a difference in the ability to cohere between these two materials and ice.

One point that should be stressed is that ice will not adhere to objects that are slightly above 32°F. This is why the heating of underwater gate racks has often been successful in reducing frazil ice accumulation.

Gale[17] observes that freshly formed frazil ice is "very sticky" and much more difficult to handle than frazil which has passed under surface ice and has not been subject to such strong cooling. This suggests that even slight increases in temperature may reduce considerably the adhesive ability of frazil ice.

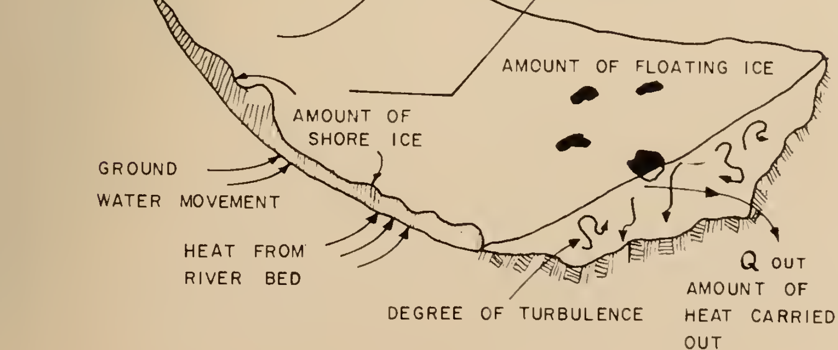
There is no doubt that frazil ice accumulations can reach gigantic proportions in an open river subjected to extreme cooling conditions. Stakle[18] gave an estimate of 476,110 m^3 per km of river for a river in Latvia. Altberg in his studies indicates that the amount of underwater ice produced in a rapidly flowing stream is often 3 to 4 times as great as the amount of surface ice produced under similar cooling conditions. Wilson[19] estimates that the mass of frazil ice floating under surface ice was from 1 to 14 ft thick for the conditions he observed. Hoyt[20] presents two examples in which frazil ice accumulations almost completely filled a stream bed.

Factors Affecting the Rate of Cooling of Moving River Water

Because frazil ice accumulations are often produced by the continued cooling of river water, a brief review of the variables affecting this cooling should be considered. The rate of cooling of a section of river water can be considered as a complex heat exchange problem which, from a practical viewpoint, will not have an exact solution. The heat exchange at the surface will be determined by the radiation, convection and evaporation losses from an open water surface. Net radiation losses will vary with the altitude of the sun, the percentage and type of cloud cover, and the condition of the water surface. Convection losses will vary with the speed and direction of the wind, the degree of air turbulence, and the air temperature. Evaporation losses will depend on the vapour pressure gradient existing between the surface of the water and the air mass, as well as the wind velocity and condition of the surface. In addition, for a given section of the river, the heat carried into and out of the section will vary according to the width, depth and slope of the river. The heat received from ground water and thermal exchange at the river bed might also need consideration.

The factors that might affect the rate of cooling of a section of river water are illustrated in Fig. 3. To calculate any one of these factors with any degree of reliability can be most difficult, especially on a short-term basis. For example, an estimate of the amount of radiation reaching the water surface can be made, if the angle of the sun's rays and the degree of cloudiness and absorptivity of the atmosphere are known. The amount of this radiation absorbed by a water surface is variable. Geiger[21] estimates that approximately 16 to 40 per cent of the total radiation from the sun penetrates to a depth of one metre, depending on the purity of the water. The long-wave radiation is almost entirely absorbed by the first centimetre of water. Whenever the water is disturbed by wind or wave action the reflectivity of the surface is changed as is the amount of radiation absorbed (Powell[22]), making precise estimates most difficult.

Fig. 3 Factors that affect the rate of cooling of a section of river water.



Barnes[1] was a proponent of the theory that radiation from the bottom of the river bed is a factor in the formation of ice on the bottom of the river bed, commonly called anchor ice. This theory is disputed by Altberg[3] on the basis that all long-wave radiation, the type emanating from the bottom of a river, is absorbed by one centimetre of water.

Barnes[1] and Loughland[23] also suggest that large amounts of anchor ice are carried to the surface during daylight hours because the radiation absorbed by the water at considerable depth heats up the water enough to release this ice. While it is true that a small portion of radiation from the sun can penetrate to depths of 20 metres (Atkins and Poole[24]), the larger amounts of heat absorbed at the surface could be carried down to the bottom layers by turbulence and thus heat the bottom surface. Another way in which the buoyancy forces of the ice might overcome the adhesive forces would be when the ice accumulation becomes great enough to float to the surface, without any decrease in the adhesive force.

The main point to be stressed is that all factors affecting the rate of cooling, as shown in Fig. 3, must be considered in an explanation of frazil or anchor ice formations.

Predicting Rate of Cooling from Meteorological Variables

Even though exact determinations of the rate of cooling of moving water would be most difficult there have been attempts to obtain quantitative estimates from meteorological variables.

The St. Lawrence Seaway Studies[25] contain an excellent review of ice formation in rivers. In this report the rate of cooling that can be expected from the difference between mean air temperature and mean water temperature is calculated. From this rate of cooling the order of magnitude of frazil ice production for special site conditions is estimated.

Wemelsfelder[26] in a more recent paper also postulates that the rate of cooling of moving water is principally dependent on the difference between the mean water temperature and mean air temperature. He presents formulae for calculating heat losses from a water surface based on this assumption. He also presents a formula for calculating the rate of heat loss when the surface of the water is partially covered with floating ice. A table is given in this paper which indicates how long it will take river water to cool to freezing temperature, provided the mean air temperature is known or can be predicted.

It must be appreciated that these formulae are necessarily very simplified presentations of a most complex situation. From the theory it is difficult to see how the wind velocity terms can be ignored in any formula. It is apparent from Fig. 3 that there are a large number of variables not included in these formulae which might have important effects on the rate of cooling of river water.

Baylis and Gerstein[15] state that, "frazil ice formed under a wide variety of wind and air temperature conditions". Ruths[27] mentions that, "with air temperatures as low as —25°C or —30°C and no wind, frazil ice will not always appear owing to the presence of a heat insulating layer of moisture saturated air on top of the water which will prevent the cold air from cooling the surface water to the critical temperature".

It also should be stressed that frazil ice is often produced a considerable distance upstream from the sections of the river under study; these geographical factors cannot be ignored in any study. Murphy[16], in 1909 suggested that very large amounts of frazil ice develop in Lake Deschenes, 3 to 4 miles upstream from the rapids near the Hull power plants on the Ottawa river.

These complications do not mean that a practical means of predicting the rate of cooling, and hence of frazil ice formation, cannot be found. They do imply that site conditions must be taken into consideration. Standing[28] gives some practical rules used at a particular plant for forecasting frazil ice as much as 12 hours in advance. On a longer-term basis Wardlaw[29] calculates the mean monthly heat losses from a water surface under winter conditions and obtains reasonable agreement with other calculated values for heat losses from open-water surfaces.

Forecasting Frazil Ice from Water Temperature Measurements

In some plants it is common practice to keep a record of water temperature. Whenever the water temperature is near 32°F and severe wind or temperature conditions are experienced. frazil ice formations may be expected.

Granbois[30] reports a method of precise water temperature measurements with an electric resistance thermometer and recorder. With his apparatus he was successful in measuring the rate of temperature change of river water and relating it to frazil ice formations. His studies indicate that frazil occurs only when the rate of temperature change is greater than 0.01°C/hr between temperatures of 0.1°C and 0°C. At temperature changes less than 0.01°C/hr a natural ice sheet is formed. Granbois in his paper gives a fairly complete description of the resistance thermometer bulb, bridge and recorder which he used.

Anyone contemplating the field measurement of river water temperature near 32°F, however, must be prepared for some problems. Perhaps the main difficulty to be overcome is that as soon as water falls below 0°C, ice begins to form on the temperature indicator.. The only temperature then recorded is the freezing point, even though there may be supercooling present. Granbois overcame this by removing the detector bulb after each successive run and melting the ice from the indicator in preparation for the next run.

Devik[2] measures the amount of supercooling of the surface layer of water with a "moll" thermopile. Special precautions were taken regarding radiation effects, including the taking of measurements just before sunrise. Nybrant[31] points out some of the problems of measuring water temperatures under field conditions. He indicated that sensitive galvanometers are difficult to use and that it is necessary to keep a measuring bridge at constant temperature and to check its calibration frequently. One must also consider the stability of the temperature sensing elements and check their calibration frequently.

Although the work of Granbois indicates that it is possible to measure river water at temperatures around 0°C to the necessary accuracy for frazil ice predictions at a particular site, special precautions and equipment are required which are usually not readily available for field installations.

Design Considerations

Although it is not the purpose of this review to go into detail regarding the design of canals, hydro intakes and racks for ice conditions, some general comments on design are included in order to complete this general review.

In 1919, Wilson[19] stated that hydro plants could be designed to be practically immune from ice troubles. Some of the standard textbooks on hydro-electric design (Creager and Justin[32]) give general consideration to the design of hydro plants to minimize frazil ice conditions.

Loughland[23] gives some general instructions for the design of sluices and canals, including the suggestion that covering the flume will prevent snow from falling into the canal, thus reducing the rate at which the water cools. Carpenter[33] indicates that by covering a flume and providing an additional supply of storage water the frazil ice problem at the Barriere Hydro Plant in British Columbia could be overcome.

In addition to the usual procedure of carefully surveying existing river conditions, ensuring proper approach conditions and locating the racks at a sufficient depth, meteorological factors should not be neglected. For example, care should be taken in determining the prevailing wind direction, for if it prevails towards the intake channel large quantities of ice will be forced into the channel. Even the direction of the wind relative to the flow of the river has a varying effect on frazil ice production. A wind blowing upstream produces more frazil than one blowing downstream because of increased surface agitation (Hendry[34]).

Once a river or canal is frozen over the rate of cooling is greatly reduced by the ice cover and the danger of large frazil ice formations is usually eliminated. For this reason considerable study has been made of the water velocities at which canals or rivers will freeze. The factors affecting the formation of ice covers on rivers or canals are generally the same as those which affect the rate of cooling of a river or canal as shown in Fig. 3.

The St. Lawrence Waterway Project[25] gives some practical information on the relation between water velocities and ice formation. Because velocity and turbulence of water are only two factors which will affect the formation of ice cover it is not possible to give limiting velocities which will apply in every case. In its report the Joint Board of Engineers came to the general conclusion that "smooth ice covers may be expected to form in rivers with velocities up to 1.25 ft/sec in zero weather providing there is no high wind preventing such action".

A committee of the Power Division of the A.S.C.E. investigated ice as it affects power plants and published a special report (Shenehon[35]). In addition to a bibliography on the subject, they give much information of use to design engineers. Some of the effects of ice on stream flow are of special interest to engineers designing canals or modifying river channels under ice conditions ([36, 37, 38, 39, 40, 41]).

Remedial Action

For established power plants and hydraulic works, it is often possible to prevent the formation of frazil ice by electrical heating. Reid[42] gives some details of the heating of rack-bars in hydro-electric plants, including a formula for calculating the power required. He emphasizes that electric heating is of particular value in locations where frazil ice develops quickly and is not of long duration. Ruths[27] gives a table of electrical values, including the power required, used in heating racks at several power houses in Norway. A report by the subcommittee of the Hydraulic Power Committee for the Canadian Electrical Association[43] gives some details of the electrical energy utilized by different companies in Canada for keeping sluice gates free of ice. Various other references are available, indicating that formations of frazil ice have been successfully combatted by electrical heating[44, 45, 46].

Steam heat has also been used for preventing frazil ice formation[43]. Dorion[47] relates some of the difficulties connected with preventing accumulations of frazil ice with steam at a pump intake.

Compressed air jets or air-bubbling systems to prevent ice formation have been applied for many years. Air bubbling systems depend on the fact that warm water below the surface can be brought to the surface by the rising air bubbles and so used to prevent frazil ice at specific locations. Skerrett[48] in 1923 described how jets of compressed air were utilized to prevent ice formation on gates of hydro-electric plants. In 1935 Skerrett[49] gave some details of how ice pressure was prevented by air bubbling systems. Other more recent papers are given by Owen[50], Simmonds[51], and Granbois[52]. Some fairly complete experiments on preventing water from freezing by means of compressed air were done by Kaitera[53] in 1948.

In addition to heat and air bubbling systems other means are being used to combat frazil ice formation. In Switzerland where, because of climatological and hydrographic conditions, frazil ice problems are not generally severe, mechanical devices to clean out intakes are used (Harry[54]). Murphy[16] reported in 1909 that frazil ice can be prevented by creating an artificial barrier across the stream to start surface ice formation.

It has been suggested by Schaefer[4] that the seeding of ponds with dry ice might hasten ice formation. Granbois[30] reports limited success by seeding river water with dry ice; the resulting fragile ice sheet was destroyed as fast as it was formed. Lavrov[55] considers that artificially increasing the number of crystallization nuclei cannot be an effective counter-measure because the intensity of underwater ice formation depends on heat losses from the stream, not on crystal number.

Additional Information The SIPRE bibliography contains many useful references on frazil ice and related problems, including a series of Russian abstracts. A few selected Russian references have been chosen from these abstracts and are listed as a Bibliography.

La Houille Blanche, (Numero 4, juillet, août 1950) contains an excellent review of snow and ice technical terms in French and English. In addition, this volume contains a general review of frazil ice problems and related phenomena.

The Meteorological Abstracts and Bibliography of the A.M.S. for July and August 1956, contain an annotated bibliography on the micrometeorology of snow covers. This would be of value to anyone studying the thermal regime at snow and ice surfaces.

This paper is a contribution of the Division of Building Research of the National Research Council of Canada, and is published with the approval of the Director of the Division.

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MATERIALS HANDLING AT CANADAIR

(Continued from page 49)

age space by increased stacking height and narrowed aisle width is a valuable contribution of improved materials handling techniques.

Waste Disposal — The removal of waste materials from work areas is a very costly item in a plant as large as Canadair's. Large annual savings were achieved in this operation as the result of an investigation made by Plant Engineering.

Formerly, wooden waste-boxes were placed at each work area. When filled, the boxes were taken to an open truck (road vehicle) into which two men dumped the waste materials by hand. The procedure was obviously costly in terms of time and manpower.

The new system uses specially-designed steel waste-bins and a high-lift fork truck with a swivelling head to dispose of the waste much more rapidly and economically.

The waste-bins, designed at Canadair, have rectangular corrugated steel bodies, fitted with lifting lugs and a towbar, and with two box-section channels underneath to take the forks of the lift truck. The chassis is mounted on four caster wheels, arranged in a diamond pattern which allows a train of several bins to follow the same course when turning corners.

According to a planned schedule, a *mule* hauls a train of empty bins around the shops, dropping off an empty and picking up a full bin at each scheduled point. When a full train has been picked up, the bins are hauled to a central loading point where a 'Sani-Van' type of enclosed garbage truck is stationed. Here, the *mule* leaves the full bins, which are then picked up by the fork truck, raised, and turned over by means of the swivelling head attachment so that the contents are dumped into the back of the large garbage truck (see cut).

Conclusion

The handling of materials in a large aircraft manufacturing plant may represent more than half the total manufacturing man-hours involved. By careful attention to improvements in materials handling methods, many thousands of dollars are saved annually.

PRECAST CONCRETE FOR WINTER BUILDING

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Presented at the 73rd Annual General Meeting of The Engineering Institute of Canada, Toronto, Ont., June, 1959.
Paper received October 27, 1959.

The protection of freshly placed concrete is one of the problems facing Canadian contractors engaged in winter building. One solution is to use precast concrete which, even in winter, can be manufactured under controlled conditions to ensure maximum strength and durability. There is, however, little experience with such units in Canada because production, although it is increasing rapidly, has been limited. In Europe, on the other hand, precast concrete has been widely used for many years. Experience there indicates that precast concrete can be used in Canada as an aid to winter construction. There are however some practical difficulties to be solved before this practice can gain wide acceptance in the industry. The most serious is that of making connections between members. Although a number of solutions have been suggested, the need for additional research is recognized.

ONE OF THE PROBLEMS facing the Canadian construction industry in wintertime concerns the protection which must be given freshly placed concrete to prevent damage from frost action. This requirement for temporary protection increases the cost of the concreting operation. When added to the increased cost of the concrete itself during the winter months it may raise the final cost in place as much as $5 per yard. There is a natural decrease in labour efficiency if protection is not provided, and a great deal of time can be lost in warming up, and sitting out bad storms.

It is common practice in Canada today to place heated ready-mixed concrete inside a temporary enclosure covered with tarpaulins or plastic, but the whole operation can be very much simplified by mixing, placing, and curing the concrete under the same roof and then assembling the precast components on the site. Protection on the site can then be confined to the joints between the precast parts. It then becomes possible to achieve the valuable economies of factory production.

Fig. 1. The all-important framework can be erected in any weather, and is immediately load - bearing. (Northview Height Collegiate Swimming Pool, Toronto).

The use of precast concrete manufactured in a factory can therefore provide a solution to the problem of winter concreting and at the same time introduce a measure of quality control not usually associated with cast-in-place concrete. The speed with which it is possible to enclose a structure when large precast panels are used promises even further cost savings.

As a part of its research study of winter construction, the N.R.C. Division of Building Research decided to investigate the present status of precast concrete in Canada and to assess the practicability of this practice being more widely used than at present. In the course of this study, an extensive search of American and European technical literature was undertaken followed by visits to engineers, architects, contractors, manufacturers, and research laboratories in the United Kingdom, the United States, and Canada.

Brief History

The practice of precasting concrete is nearly as old as the use of reinforced concrete. Development was slow until World War I when, because of shortages of conventional materials, many nations investigated the possibility of precasting concrete on an industrial basis. By 1930, Germany was producing precast concrete frames, girders, columns, sewers, bridges, fence-posts, lamp-posts, formwork, paving block, and building block, and had already recognized the advantages of precast concrete for winter construction.

In the years following the revolution, much attention was given in the U.S.S.R. to the manufacture and use of precast concrete. So convinced were the authorities of the advantages of this system that by 1934 standard precast concrete structural units were required for all commercial and industrial buildings. By that time precast units weighing 15 metric tons were being fabricated. In contrast to this rapid development in other parts

Fig. 2. Precast concrete roof and frame provide the structural portion of a lightweight enclosure (University of Saskatchewan).

of Europe, little early work was done in the United Kingdom or the United States. Precast floor systems had, however, been developed and were quite widely used, and as early as 1906 American railroads were using some structural precast concrete bridge components. The erection of such large components was no problem to the railroads who could use their heavy wrecking cranes.

The construction industry generally had to wait for the development of the heavy-duty motor truck crane and tower crane before full use of precast building components was possible. The steel shortage brought about by the Second World War resulted in a great increase in the use of reinforced concrete. Much of it was cast *in situ* but with experience came the realization that precast concrete offered a low cost, high quality material that could often replace traditional materials. In the United States the use of precast concrete frames for commercial and industrial buildings increased and large precast girders, which had been used in earlier years, were again used in bridge construction. With the development of prestressing techniques and the introduction of heavy lifting equipment, precasting in the United States began to compete seriously with conventional materials.

Today much use is made of large floor and roofing slabs and tilt-up wall panels, precast on the site and put in place by special erection equipment. At the same time factory precasting is also widely used and has made possible the erection of one factory building at the rate of 7500 sq. ft. per day, with framing and roof decking averaging 10,000 sq. ft. per day.

The precast, prestressed concrete industry in the United States maintains a yearly growth in production of 200 to 300%. At present there are some 200 precast prestressed plants in operation, and a further 150 are under construction or being planned. Girders and beams of I, T, WF, and rectangular sections, roof and floor slabs of double T and channel section, joists of I and T section, rigid frames, trusses, columns, poles, pilings, lintels, bleachers and wall panels are being produced in ever-increasing quantity.

Although the general adoption of concrete column-and-beam frameworks in Britain has been slower and is even today less widespread than in the other countries of Europe, precast floors and rigid frames for single-story industrial buildings are now generally accepted as standard forms of construction. Some manufacturers can produce precast concrete frames at the same price as unprotected steel and at half the price of fire-proofed steel. In an effort to conserve steel and provide schools as cheaply and quickly as possible, the British Ministry of Education sponsored the development of a number of proprietary systems. Their success may be illustrated by the fact that one contractor, using a system of precast units prestressed in place, has built between 40 and 50 schools in three years and is now entering the commercial building field.

In the U.S.S.R. today, precast concrete is being used almost exclusively for building construction. In Moscow and Leningrad alone, some 86,000 apartments to be built in this way are planned for 1959, mostly in five-story blocks. The finished buildings have a neat appearance both inside and out, but the precast products are roughly finished and are generally covered by plaster or brick facing. State control and co-ordination of all construction, and the resulting standardization throughout the country, has permitted the complete mechanization of even pretensioning operations, through the development of continuous wire winding machines and rotating casting beds.

Factory Manufacture

Precasting does not automatically imply factory manufacture nor that it cannot be considered beyond the economical hauling distance from an existing factory. On-site manufacture, however, is generally limited to heavier components that are too difficult to transport, or to large jobs where it is economically practicable to erect a temporary factory. A $300,000 job is regarded in Europe as the minimum size for on-site casting, because this will allow recovery of the cost of plant, moulds, and planning during the course of that single job. On-site manufacture in Canada is generally left to the factory manufacturer who can extend his operation in this way. At present, he has the necessary specialized knowledge, and this situation will probably continue until standard specifications for precast concrete are available. There are exceptions to this general rule, but these usually result from very close co-operation with an experienced architect-engineer. At the present time building codes make virtually no distinction between precast concrete and ordinary reinforced concrete cast-in-place, so that they give no indication of the extra care required with precast work.

Factory production, whether in a permanent or a temporary factory, permits rigid control of mixing, placing, and curing, as well as being completely independent of weather. Hence it is possible to produce high strengths running as high as 9,000 to 10,000 psi, even with lightweight concretes. The central feature of a precasting factory is the concrete mixing plant, operating on a weight batching principle, and similar in all respects to that commonly used in modern ready-mix concrete plants. Some are electronically controlled. In all cases there is some form of continuous inspection and of random sampling, frequently by an independent testing laboratory.

From the mixing plant the concrete is transferred to the casting bays, which frequently operate on a long-line principle. Here the forms are assembled, the reinforcement placed and possibly prestressed, and the concrete compacted and cured. For smaller units and where rapid production is desired, steam or warm water curing is used; with prestressed units, this permits stress release after as little as 12 hours. Larger units may be air cured, which permits stress release in three days. With either method the side forms are stripped and re-used on a daily basis. For winter operation of outdoor casting bays either on the site or at factories, forms are heated by the circulation of steam, hot water, or hot oil.

The continual re-use of standard forms makes it possible to use steel forms. Besides reducing form maintenance costs and producing accurate castings, steel forms produce a smooth finished surface ready for painting. The savings involved in factory production of an integral surface finish are very real and can reduce the construction time very considerably. The exposed face of a wall panel, for example, may be tiled, trowelled smooth, brushed, polished, or treated with an acid solution or water spray to expose the aggregate. It is possible to achieve almost any desired texture or colour, and at the same time to produce a finished surface that requires little or no maintenance. The application of special finishes of this type to a cast-in-place panel would be costly, if not impossible, and would require additional winter protection.

The precast units are easily handled in the factory, usually with gantry cranes. Some factories that use a vacuum process to remove surplus water from the compacted concrete also use a vacuum mat pick-up for handling precast components, particularly wall panels. The finished units can be stored under cover if necessary, and standard units can be stockpiled during periods of low demand so that factory production can be maintained at a uniform year-round level. Most units, however, are produced to order and stored until they have reached the required strength, which incidentally means that they have undergone most of their shrinkage. They can be delivered to the construction site in sequence of erection. On well-planned jobs they can be lifted directly from the delivery truck to their final positions. This eliminates on-site storage completely and is a great advantage in wintertime. Erection of precast concrete may depend on solid ground conditions for heavy erection equipment; in this respect it is also more suited to winter than to summer construction.

Fig. 3. The lift slab method is an ideal winter construction method because the concrete slabs can be placed with a single enclosure at ground level (Carleton University Arts Building, Ottawa).

Simplification of Construction Operations

The quality of precast work and the possibility of using prestressing techniques with it are not the only reasons for its increasing acceptance. Simplified construction procedures result in major time and labour savings, which can in turn reduce building costs considerably. The elimination of framework on the construction site is a big factor in reducing costs. Forms must be used, of course, in the precasting plant, but through re-use their number may be greatly reduced. The amount of formwork is also reduced by casting the units in the most advantageous position. A concrete staircase, for example, is best cast upside down in a horizontal form. A vertical wall panel with a double grid or reinforcement is a difficult section to place on the job, but in a precasting plant the concrete can easily be placed in the open face of a simple horizontal form.

In Europe, savings of two to three hours per cubic yard have been recorded for panels of this type. The over-all saving made by using precast concrete for a French apartment building amounted to 50 per cent of the formwork, or from 10 to 15 per cent of the total cost of the building. Construction times are commonly cut in half. One British contractor has found that it pays to redesign cast-in-place buildings as precast structures simply to take advantage of modern methods and equipment. He has achieved such results as being seven months ahead on a 30-month schedule with a job little more than half finished. Such time savings can greatly reduce overhead expenses and interest on capital. They can result in earlier occupancy, and hence in earlier receipt of rents. In the construction of an apartment building in Europe, four months were saved by using precast concrete instead of concrete cast-in-place. The resulting savings, together with the earlier receipt of rents, more than offsets the cost of 30,000 miles of trucking from factory to job-site and of importing and setting up a special crane to handle the precast units. In Canada, because of the long winter season and the desire to close in buildings in the shortest possible time, saving of construction time is of great importance. Precasting avoids cold weather delays. It can eliminate the need for temporary enclosures of any kind and can provide, in itself, an immediate and permanent shell to shelter the work of sub-trades.

Although the labour force required to erect precast concrete is small, it must be highly skilled. In the United States a trained crew of six men erected the frame of a two-story, 17,000-sq. ft. building in four 8-hour working days. In another case, six men erected the frame of 64,000-sq. ft. single-story building in ten working days. Factory processes make best use of less skilled labour and make it possible to build up experienced teams that benefit from year round employment. Experience in the U.S.S.R. has shown that the use of precast concrete leads to an over-all labour saving of as much as 48% for the individual components, compared with monolithic members. In housing, where large precast wall and floor panels are used, labour on the building site has been reduced by as much as 55%, compared with cast-in-place construction.

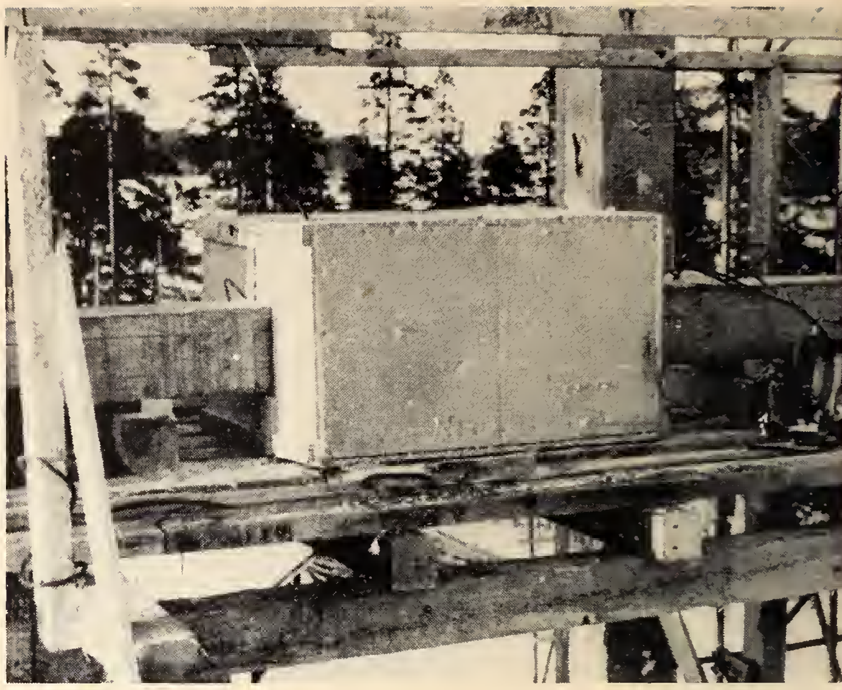

Fig. 4. Joints made with cast-in-place concrete require winter protection. This fibreboard box could be heated with a single electric light bulb.

Connections Between Precast Units

The advantages of using precast concrete are often offset by the difficulty of producing satisfactory connections between precast units. A number of special systems of jointing have, however, been developed. Some are well suited for winter construction, but others require cast-in-place concrete which must then be protected by portable shelters or other means.

There are four main types of joints in common use:

(1) Welded reinforcement joints;
(2) Rigid metal joints;
(3) Prestressed joints;
(4) Cast joints.

The welded joint connects reinforcing bars which have been left exposed during manufacture of the precast units. Only a small space is left between units and this space is later grouted. Rigid metal joints are made by steel connectors consisting of short lengths of structural steel, anchored into the ends of the units to be joined and tied into the main reinforcing by welding. The joint is made by bolting, riveting, or welding the connectors.

Prestressed joints are made by precasting steel reinforcement which is anchored in both units being connected or by using prestressed bolts. This system, which is considered by some experts to be the best one, gives a joint which is able to resist the bending moments as well as the shearing forces which must be carried. Cast joints are made by splicing the ends to be joined with reinforced concrete which is cast-in-place. In such a joint the compressive loads are carried by the concrete filling, while the tensile loads are transferred through the reinforcement which is spliced, or by bond between the reinforced concrete splice and the precast units.

An ideal joint design for precast concrete framing should satisfy three major requirements:

(1) The joint should provide bending moment strength to the maximum possible extent;
(2) It should be economical, with the least possible use of extra steel and labour; and
(3) The joint should allow exact plumbing of a column after it has been erected.

Maximum moment resistance is particularly desirable for large warehouses and industrial buildings, because it is most often very difficult to obtain lateral stability in any other way than by fixing the columns to their foundations. To obtain this maximum rigidity, the reinforcing steel over and under the joint should be made continuous as far as possible. This is most easily achieved by means of welding; it is easier to obtain the desired quality when all of the steel reinforcement is marked according to steel type and yield strength.

To reduce the amount of extra steel required, footplates, for example, should be made as thin as possible and should not be depended on to transfer bending stresses except in the initial stages before final welds are made or filling concrete added. In wintertime, it is a definite advantage to have a rigid metal joint which is capable of taking the construction loads without the assistance of the filling concrete. This concrete can be added at a later more convenient time after the building is closed in. In most instances, the labour involved in making the joint is more significant than the extra material used. Erection time is very expensive and should be kept to an absolute minimum.

For most parts of Canada the rigid metal joint is the most attractive for winter construction projects, but it is also the most expensive. For this reason, one of the other joint systems is generally used and provision made to ensure that no frost damage occurs to the grout around the joints. A good grouted joint is often harder to achieve than generally believed. Frozen members must be heated before the grout is applied. Some engineers believe that porous members can absorb even the water required for hydration of the cement. Temperature, shrinkage, and loading movements are often ignored. Early failures of grouted systems have been attributed to one or other of these conditions. Some designers find it an advantage to use a cast-in-place core for stability. This eliminates any uncertainties about joints between the precast members, and has been shown to fit in particularly well with the general contractor's operation.

Canadian Practice

There are approximately 20 manufacturers in Canada who produce structural precast and prestressed concrete. Over half of them are to be found in or near Montreal or Toronto. Although the greater part of their business is still done in hollow cored and double T floor and roof slabs, a few have now increased their regular production to structural frameworks, sandwich panel walls, and large architectural facing slabs. Some extend their field of operations by site-casting and post-tensioning outside their own area. Precasting is now a $25 million a year business. All the companies report that each year's production is higher than that for the previous year. One company has increased its production six-fold in three years.

A lack of standardization has kept the industry from enjoying the full benefits of factory precasting. Competition is keen, and because of this manufacturers are forced to work very close to design limits. These problems are recognized by the industry but there is some reluctance to establish standard sections on the grounds that such action may restrict the development of this relatively young, rapidly expanding industry.

Canadian designers confirm the advantages of precast concrete for winter construction. In order to make the best use of the precasting method, a designer should be able to co-ordinate architecture and structure. He should have a basic knowledge of the manufacturing processes as well as the construction operations and the equipment used to handle precast components. Better than average supervision of the job must be provided. In short, all the problems facing architect, engineer, manufacturer, and contractor must be considered in the very early design stages. This collaboration encourages new thinking; in many cases the savings resulting from a new method of approach have exceeded those forecast for the precasting method itself.

Conclusion

The use of precasting can limit on-site concreting operations in wintertime to the making of the joints between the precast parts. It can halve construction time and ensure top quality products. Not unnaturally its use is expanding rapidly in Canada. Much of the production of Canadian plants is still restricted to floor and roof panels, but to an increasing extent structural members such as beams, columns, arches, purlins, and load-bearing wall sections are being produced. Full development of this new industry would seem to be restricted by the lack of information in the offices of engineers and architects, and by some hesitation on the part of designers and contractors to full consideration of this new method and the necessary techniques.

As with all building materials, there is still a great deal to learn about precast concrete but this need has been recognized. The American Society of Civil Engineers and the American Concrete Institute have formed a joint committee to study it. One of the first projects to be undertaken by this new "Committee 712" will be an investigation of joint systems for use between structural precast members. From such studies, an increasing fund of knowledge will be accumulated for the use of designers in this country. In the meantime, there is sufficient evidence already available to show that precast concrete has an important place in Canadian wintertime construction, a place long established in northern Europe and Russia.

Acknowledgements

The authors wish to express their thanks to all the engineers, architects, contractors and manufacturers in Canada, the United States, and Great Britain who gave so generously of their time and experience in discussions and whose comments are summarized in this paper.

Fig. 5. Factory storage under cover avoids on-site storage problems in winter and allows complete curing in controlled conditions.

This paper is a contribution from the Division of Building Research, National Research Council of Canada and is published with the approval of the Director of the Division.

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TESTS OF HYDRAULIC TURBINES

An Appraisal

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

EFFICIENCY and capacity tests of hydraulic turbines have engaged the attention of the writer for nearly fifty years, and recently he carried out tests of the largest turbines in the world at present in service. The range of heads has varied from 16 ft. to 1,130 ft. and of capacity from 200 h.p. to 200,000 h.p. Quantity of water used has been measured by four different methods, but several other methods have been observed or studied. The Gibson Time-pressure method has been chosen for a majority of these tests, but in that regard the writer does not differ from others who have specialized in such tests, each confining his work largely to one method.

It is proposed in this paper to make an appraisal of the value of tests, to describe briefly several of the methods used for measurement of quantity of water flowing and to comment on tests of models of turbines, Test Codes and several other related matters.

Tests of turbines in place as a rule involve some considerable expense and sometimes interfere to greater or lesser degree with the normal operation of the plant in which the turbine is installed. It is reasonable therefore to consider why tests should be made.

The economics of the problem must of course be the determining factor although a long range view should be taken of this. Consider a power plant costing $30 million, comprising two generating units. If the turbine of one unit has an efficiency of 90% over the usual range of operation and the other 88%, the loss of investment represented by the deficiency of 2% in half the plant amounts to about $240,000. Turbine efficiencies over the years have been increased by a much greater amount than 2%.

In the majority of the acceptance tests carried out by the author the efficiency and capacity guaranteed have been realized. There have however, been quite a number of turbines which have failed to attain the maximum efficiency guaranteed, more which have failed to reach the expected efficiency, a lesser number which have failed to have a maximum output equal to that guaranteed and others, intended for continuous use at full output, which have fallen off badly in efficiency as they approached full gate opening. Having in mind the capital value of small increases in turbine efficiency it is certainly in the interests of the purchaser to assure himself by tests that the equipment conforms with the guarantees named in the contract.

There are also secondary benefits from the tests. In multi-unit plants the best overall efficiency of generation requires that the total load on the plant be properly distributed among the units and that the right number of units be in operation to secure this optimum efficiency. The only way to determine the proper number of units and the distribution of load among them is by analyzing the efficiency curves.[2,3] If surplus water is available this does not apply but as a rule, for the major part of the year at any rate, economy of water is an important consideration particularly in the case of developments depending on stored water.

The tests also enable a continuous record of water used to be made a part of operating records.

Considering the value of tests to the industry in general, a review of the experience on this continent over the past hundred years is of interest.

In 1859-60 tests were made of 16 turbines at Fairmount Park Water works in Philadelphia. The weighted average of the maximum efficiencies of these turbines was 72.5%. At the Centennial Exhibition at Philadelphia in 1876, eighteen turbines were tested and showed a weighted average of the maximum efficiency of 75.5%. Turbine manufacturers used the facilities of the testing flume of the Holyoke Water Power Company, at Holyoke, Mass., to test and improve their product, but because the results of these tests were treated as the property of the commissioning manufacturers, a complete record of progress in the industry is not available. However, complete records[1] are given for twelve turbines of various makes and sizes tested in 1896-98. The average of their maximum efficiencies was 83.6%, the highest obtained being 85.4%.

The improvement of 11% over this 40 year period was probably paralleled by a similar improvement in the product of European manufacturers. The North American manufacturer generally produced a series of turbines of similar design and in various sizes, whereas the European manufacturer built turbines fitted to the project in hand. Two turbines installed by European manufacturers at developments in Austria and Switzerland in the late 1890's showed efficiencies of 85 and 86% respectively—figures quite comparable with those recorded in the previous paragraph.[4]

The generation of electrical energy in central stations and its distribution to industries located at some distance from the source of power in the latter part of the 19th century opened the field for the use of larger generating units and gave an advantage to the European turbine manufacturers. In the early years of the present century most of the turbines installed in central stations—notably those at Niagara Falls—were of European manufacture, and tests when made indicated efficiencies of the order of those recorded above. Refinements in design not only in the turbine runners but in gates, scroll cases and draft tubes were responsible for progress in the attainment of higher efficiencies. In one of these plants units were installed in groups of 2 or 3 as power demands increased over a period of about ten years. One of each group was tested by the author a few years later and it is interesting to note that, with one exception, each group showed an improvement in maximum efficiency over the previous group.

During the early years of the century improvements in design and settings of turbines resulted in greatly increased turbine efficiencies, and by 1925 efficiencies in excess of 93% were attained in a number of instances. Laboratories were established by most manufacturers of turbine equipment, improved methods of testing were developed and at least two new methods for the precise measurement of large flows presented. These are The Allen Salt Velocity Method[5] and the Gibson Pressure-Time Method[6,7] The consistently high efficiencies attained by modern turbines are the outcome, in part at least, of the large number of field and laboratory tests that have been made during the last forty years. Dr. Gibson in a recent paper[7] presents the results of 206 field tests by the Gibson Method since 1920, 75% of which showed efficiencies in excess of 90% and 10% in excess of 93%.

Field Tests of Hydraulic Turbines

The quantities to be measured in the test of a turbine are (1) The head acting (2) the power output and (3) the quantity of water passing through the turbine. Brief comment on the first and second of these will be made later. In the four following sections descriptions are given of four different methods commonly used for measurement of the third item.

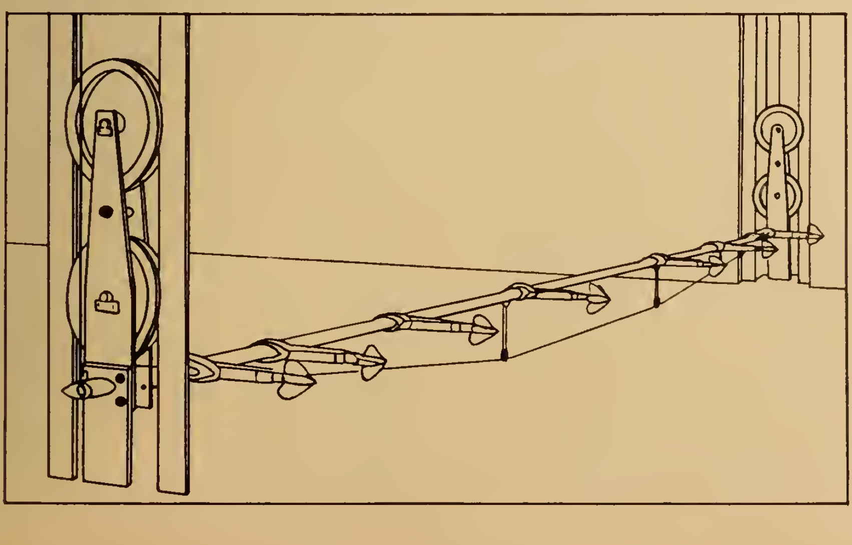
The Current Meter Method

Current meters fall into two classes, namely those with horizontal axis and those with vertical axis. The former usually has four inclined blades supported by radiating spokes (bladed meters) or two or more helical vanes mounted directly on the shaft (propellor meters). The backward thrust of the shaft is taken usually by a jewelled thrust bearing within the meter housing, which also contains electrical contacts to enable a record of revolutions of the meter shaft to be transmitted to a convenient observing or recording post.

The vertical axis meter carries on its shaft four to six hemispherical or cone shaped cups. The shaft is supported on a protected steel pivot and, above the cups, there is a housing for the electrical contact for counting or recording revolutions of the shaft. The vertical axis meter is the type generally used on this continent for measurements of stream flow, for which purpose it has great advantage over the horizontal axis meter.

In stream flow measurements the vertical axis meter is generally supported on a cable or fine wire and provided with a tail-fin which causes the meter to face the direction from which the water in contact with it is flowing. If a moment's thought is given to the use of the vertical axis, or cup type meter, it will be realized that, even if rigidly supported, the full velocity of a horizontally divergent current will be recorded, not the resolved part of this normal to the metering section. If the divergence is in the vertical plane the meter is found to under-register the resolved part of the velocity. This meter, therefore, is not favoured for turbine tests.

Fig. 1—Lightweight meter frame carrying seven meters and movable vertically in stop-log checks.



When meters are used for turbine tests they are of the horizontal axis type and they are rigidly supported with the axis at right angles to the measuring cross-section. If the water flows past the meters at an angle other than normal to the metering cross-section they record approximately the resolved part of the velocity normal to the cross-section. If the angularity of the current does not exceed 8° the recorded velocity will be within 1% of the resolved part of the velocity normal to the metering section.

Current meter manufacturers in Europe for many years have studied and improved their product and one of these claims for certain instruments of this component type is that they record the resolved part of the velocity normal to the metering section for angles of inclination far in excess of the figure given above, in fact, for one type, about 45°. Many other meters record the resolved part of the velocity normal to the metering section at angles well in excess of 8°.

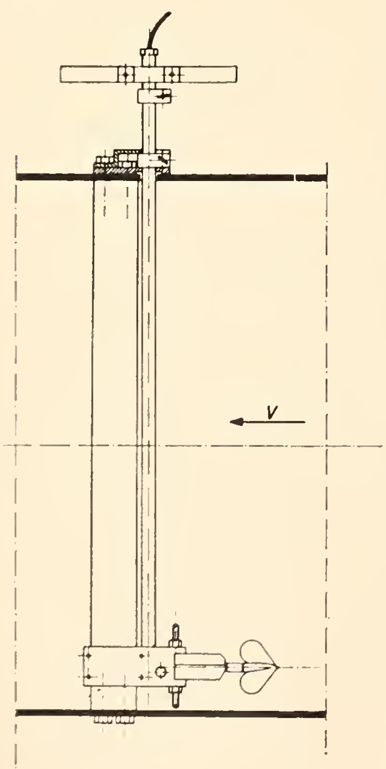
For low head plants it is the usual practice to meter the flow at the intake or in the intake canal where the flow is likely to be less disturbed than at other points along the flow path. It is customary to mount a group of meters on a steel frame moveable vertically, in stop log or gate checks if at the intake, the meters being suitably disposed as to define, as accurately as possible, the variation of velocity across the intake or canal. A light-weight metering frame is shown in Fig. 1. The frame is then lowered until the meters are at a pre-determined distance below the top of the metering section and readings of the various meters transmitted to a chronograph over a measured time interval (also recorded on the chronograph), the time of record being at least one hundred seconds. The meter frame is then lowered to various pre-determined levels in the metering section at each of which the meter readings are recorded. The spacing of the vertical points of measurement is so chosen as to properly define the vertical velocity curve. The position of the meters on the steel frame and the lowest point of measurement should place the meters not more than 8 ins. nor less than 3/4 of the diameter of the meter wheel from the boundary of the metering section.

The number of metering points is defined in various test codes, all differing slightly. The formula considered most generally acceptable, as it conforms closely with a new international code now in preparation, calls for a number of metering points from 10 and 16 times the cube root of the area of the cross section in sq. ft. For example for a metering section 10 ft. by $12\frac{1}{2}$ ft., 50 to 80 metering points are required.

The metering section must be definite in area and susceptible of accurate measurement. An arrangement used by the writer in measurements at a small plant with a curtain wall at the intake extending well below water surface is illustrated in Fig. 2. The meters in this case were mounted on a steel frame moveable in stop log checks and the nose of the meters came within an inch of the timber bulkhead. The arrangement does not comply fully with the test code but was considered satisfactory. In this case the area of the metering section was definite and was measured before the plant came into service. Flow at all points was normal to the section or nearly so. However, European practice would demand a bellmouth upstream from the section to further assure streamlined flow. Even in flow measurements in a canal a bellmouthed structure might be used which would have the added advantage of keeping the area of the section independent of variations in water level.

In European practice by far the larger number of turbine tests are made by current meter even in penstocks from 4 ft. diameter and upward. Various arrangements for supporting the meters are used, two of which are illustrated in Figures 3 and 4. For small penstocks smaller meters are used than for open channels or for large penstocks. The minimum distance of the meter from the wall of the penstock, as for open channels, is usually 3/4 of the diameter of the meter wheel, and the spacing of meters across the diameter is such as to give approximately equal weight to the records of each meter. Measurements are usually made on two diameters. Conductors are led from each meter to a recording chronograph and, if a single meter is used, the reading for each position continues for at least one minute or, if a group of fixed position meters are used over a full diameter, readings continue for at least five minutes.

Fig. 3—Measurement in large penstock with high velocity of flow. Single moveable meter sliding along permanently mounted rod.



The metering section in a penstock is chosen if possible at least 20 penstock diameter downstream and 5 diameters upstream from the nearest bend. Manifestly in many large penstocks it is difficult to conform with these conditions in which cases the flow conditions at the metering section are carefully examined prior to the test.

The Allen Salt Velocity Method

This method, developed by the late Prof. C. M. Allen of Worcester, Mass., might be considered as a positive or volumetric measurement. The method, applicable to closed conduits, is based on the fact that salt in solution increases the electrical conductivity of water. A salt solution is injected at a section in the conduit upstream from two seats of electrodes suitably spaced along the conduit and its passage at the electrodes, together with the elapsed time of its passage, is recorded on a graph. An accurate measurement of the conduit enables the volume between the two sets of electrodes to be computed in cubic feet, V, and, if the time of passage is t seconds, the discharge in cubic feet per second is

$$Q = \frac{V}{t}$$

No empirical coefficients or corrections are used.

Usually, as indicated above, two sets of electrodes are used. In a rectangular conduit these may consist of a series of pairs of iron pipes, the pipes in each pair being a few inches apart and insulated from each other and from the conduit. They are installed parallel with the walls of the conduit and extended from top to bottom. In a circular pipe the bars are so spaced as to give equal weight electrically to equal areas of pipe cross-section. The two banks of electrodes are spaced at such a distance apart that the passage of the salt solution from one to the other at full load is at least nine or ten seconds.

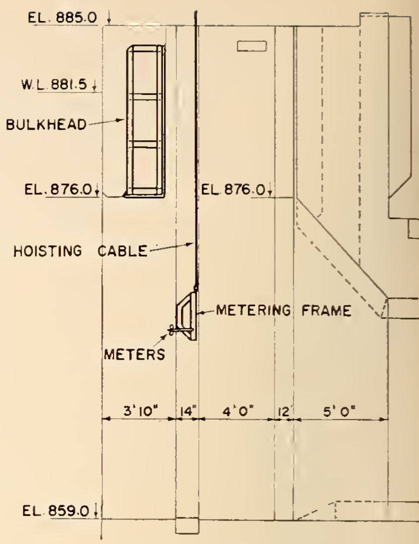


Fig. 2—Bulkhead installed at intake of low head plant to develop a satisfactory metering cross-section.

The salt solution is injected into the conduit under pressure through a system of piping and pop valves controlled by a single quick opening valve.

In some cases only one set of electrodes has been used and the time from injection of the salt solution to its indication at the electrodes is measured. In such cases the volume of conduit from the pop valves to the electrodes is the V of the above equation.

The electrical record of passage is usually made on a direct writing oscillograph with variable speed. A typical chart is shown in Fig. 5. The record shows clearly the passage of the salt solution at each bank of electrodes and, at the top of the chart, a record of time by seconds marked by a chronograph pen actuated by a seconds pendulum or some other precise timing device. The area marking increased amperage as the salt solution passes is marked off and its centre of gravity determined. The time indicated by the location of the c. and g. is taken as the time of passage of the salt solution.

The method has probably a broader field of application for closed conduits than any other method. It has been used successfully in comparatively short converging passages such as are common in low head plants and in circular penstocks of all sizes. Its accuracy has been confirmed by many tests in which other methods of water measurement have also been used. A record of some of these comparisons will be found in Table No. 1.

The method has been used in the laboratory and field in open channels. In such cases the measurement of volume is more difficult because of the free surface.

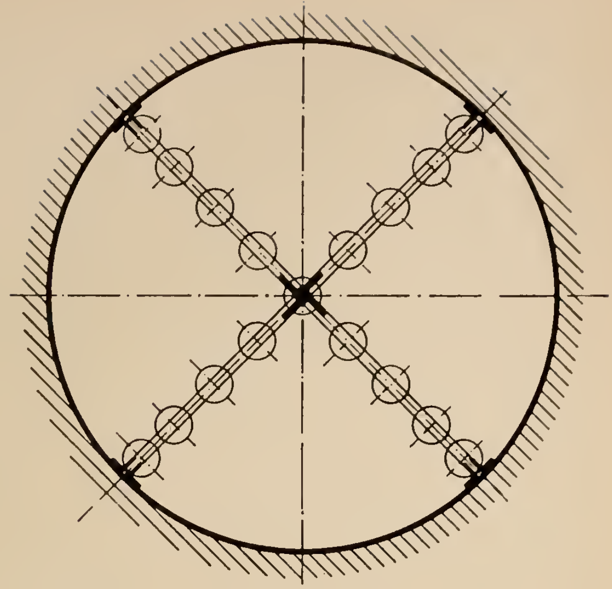


Fig. 4—Measurement in large penstock. Cross-shaped frame supporting thirteen permanently mounted meters.

The Gibson Pressure-Time Method

This method, invented by Dr Norman R. Gibson of Niagara Falls, N.Y., in 1919 is an application of Newton's second law of motion. This second law may be written in the form "The total change of momentum is proportional to the impulse of the applied force".

Consider a mass of water M in a penstock moving with a velocity v feet per second. Its momentum is Mv. If the turbine gates are closed in r seconds so that the velocity is reduced to zero the change in momentum is Mv. Some force P has acted upon this mass to bring it to rest and the impulse acting on the Mass M is Pt. Thus if quantities are measured in dynamical units.

$$Pt = Mv$$

The Mass M can be computed by making a survey of the penstock. If the impulse Pt is measured the only unknown in the equation is v from which the discharge is readily computed.

In practice a differential mercury u-tube is connected to peizometers at two sections of the penstock and one leg of the u-tube, a glass tube, is set up in front of a special camera at the rear of which a photographic film on a revolving cylinder records the movement of the mercury in the u-tube. A high intensity light is set up in front of the u-tube and a seconds pendulum in front of the lens cuts off the light each second, recording time on the film which is usually 11 x 18 in.

The glass tube through which the movement of the mercury column is observed is usually 1/2 in. or 5/8 in. outside diameter of uniform internal diameter and the other leg of the u-tube consists of a honed steel tube of a diameter suited to the test in hand. The glass tube is fixed to the front of the camera and its distance from the lens is such that the movement of the mercury is precisely duplicated on the film.

Instead of a single piezometer usually two or four piezometers are installed at each of the sections in the penstock. These are joined by a ring of piping around the penstock or, alternatively, by separate pipes led to outlets at a point convenient for connection to the Gibson instrument. The mass of water brought to rest, the M in the formula above, is that in the penstock between cross-sections through the two sets of piezometers.

As originally devised a single set of piezometers was used and the u-tube was of the simple instead of the differential type with the leg containing the steel riser open to the atmosphere. The mass of water brought to rest then extended back to the penstock intake and an additional measurement of variation in water level at the intake during closure was necessary. The simple set up is seldom used now. The method herein described is known as the differential method.

In Fig. 6 is shown a reproduction on a reduced scale of a Gibson diagram from a test of a turbine when developing 15956 hp. under a head of 104.6 ft. The closure of turbine gates commenced at point A and was completed at point B_1. The level of the mercury in the glass tube at beginning of closure was at the horizontal line through A and after the harmonic fluctuation of the mercury column have ceased, in about 30 seconds, it was at the horizontal line through B. The vertical lines are those marked on the film by the pendulum as it swings in front of the lens. On this film they are 0.814 in. apart. The position of point B_1 and the recovery line are computed from the information on the diagram but no explanation of this part of the computation will be attempted here. They are described in considerable detail in references 6 and 7.

In that part of the diagram above the recovery line from A to BB_1 abscissae measure time. Ordinates, measuring the movement of the mercury column, are proportional to pressure and the area

Table I
Comparison of discharges measured by two or more methods.

Location	*Method*					
	Weir	*Current Meter*	*Volumetric*	*Gibson*	*Allen*	*Thermometric*
Cornell			1.000	1.002		
Shawinigan				1.000	1.000	1.000
Muscle Shoals	1.000			993		
Conowingo				1.000	1.001	
Parahyba				1.000	1.004	
Walchensee		1.000		.997	.998	
Gitting		1.000		1.004		
Munchen			1.000	.997		
Brunnenmuhle	1.000			1.014		
Brunnenmuhle	1.000			.996		
Moshier				1.000	1.001	
Pandora			1.000	.998		
Parahyba				1.000	1.004	
Montpezat		1.000				.996
N.D. de Briancon	1.000					1.005
Glandon		1.000				1.003
Fabian		1.000				1.004
Baous		1.000				.994
Kinlochleven						
" Preliminary		1.000				.998
" Series I		1.000			.998	.985
" Series I		1.000			.985	
" Series II		1.000			.982	
" Series III		1.000			.993	
" Series IV		1.000			.998	

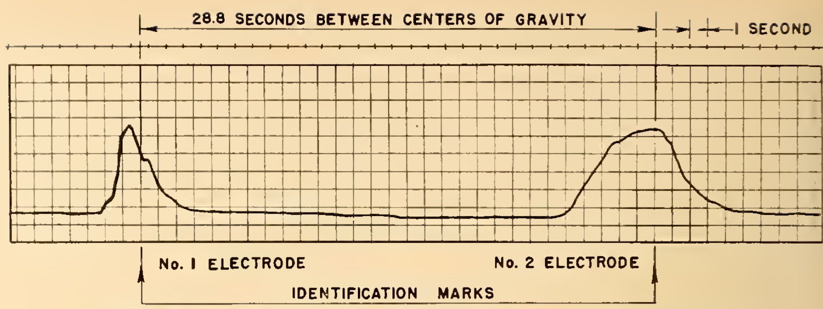
of the diagram therefore is a measure of the impulse or Pt.

The diagram measures the flow cut off as the turbine gates close. There is always leakage past the gates, usually less than one half per cent of the full gate flow. This is measured by a separate turbine gate leakage test and added to the flow recorded by the diagram.

An expert looking at the diagram in Figure 6 will detect at once that closure of the turbine gates was not complete at B B_1 but was at C. The area at C is very slightly greater than at B B_1 but for simplicity in this explanation closure is assumed to have been completed at B.

The method is most readily applicable to measurements of flow in circular penstocks or conduits of any diameter having a sufficient length to give a satisfactory impulse during closure of the turbine gates. Test codes usually demand that the product of length between piezometers and velocity of flow in the penstock shall be at least 200. It is not necessary that the penstock be straight or of uniform diameter. The method has been successfully applied in the short converging concrete conduits common in low head plants.

Many attempts have been made to apply the principle of the method by other devices than the instrument designed by Dr. Gibson, some of them simulating the steam engine indicator. All of these so far built have been inferior in operation to the simple mercury u-tube used by Dr. Gibson.



VOLUME OF TEST SECTIONS BETWEEN ELECTRODES = 5345.37 CU.FT.
AVERAGE TIME OF PASSAGE (ALL SHOTS) = 28.88 SECONDS
DISCHARGE (5345.37) ÷ (28.88) = 185.089 CU.FT./SEC.
=(185.089)(1728)(60) ÷ 231 = 83,074 G.P.M.

Fig. 5—Typical chart from Allen Salt Velocity Measurement.

The Poiran Thermometric Method

This method differs from those described in that it does not measure the quantity of water but instead measures the loss of energy or more properly the mechanical energy converted into heat as the water passes through the turbine. The method is based on the principle of equivalence of mechanical energy and heat. Some attempts to make use of the principle to measure the efficiency of turbines have been made in Germany and Canada, and probably elsewhere, but the technique was somewhat different from that developed by the engineers of Electricité de France.[9]

In tests conducted by The National Research Council (Canada) in cooperation with the Shawinigan Water and Power Company at Grand' Mere[8] the increase in temperature of the water between entrance to and exit from the turbine was measured by a pair of very accurately calibrated thermistors. This increase in temperature when converted to its equivalent in mechanical energy (per lb. of water) represents the part of the net head converted into heat (and lost) and enables a computation to be made of the turbine efficiency. Manifestly identical and very accurate thermistors must be used to measure the very small temperature differences. On the other hand this method measures a small quantity namely the losses which may be only 7 or 8% of the total energy whereas in other methods the useful energy generated possibly 92 or 93% of the total energy. An error of 20% in the losses is equivalent to only about 1% in the end result, the efficiency.

The technique used by the French engineers differs from that used at Grand' Mere in that the change of internal energy of the water at entrance to the turbine is determined for an adiabatic expansion which brings it to precisely the same temperature as the water in the tailrace.

In practice a probe is inserted in the penstock upstream from the turbine casing and through this a small quantity of water flows through an expander, with controllable head loss, and thence through a well insulated pipe to a measuring enclosure, also well insulated against heat loss. In this measuring enclosure a platinum resistence thermistor is placed and an identical thermistor immersed in the tailrace water. The thermistors have been previously calibrated by placing them in the same water bath and determining the setting of a Wheatstone bridge when the two thermistors are at the same temperature. It is claimed temperature differences of 0.001 of a degree can be detected. Investigations have indicated that considerable latitude is permissible in locating the probes and confirmed the uniformity of temperatures at all points in the penstock and tailrace for all ordinary cases.

The pressure in the measuring enclosure is now reduced by controlling the flow coming through the probe until the Wheatstone bridge is balanced and the temperatures in tailrace and the measuring enclosure are, therefore, the same. The pressure in the measuring enclosure is then accurately measured and its temperature observed (to tenths of a degree C.) The flow from the measuring enclosure is then cut off and the pressure there, which is now the pressure in the penstock, is measured. Special equipment enables these pressures to be very accurately determined.

Very briefly the theory on which the determination of the efficiency of the turbine is made is as follows:

The energy supplied to the turbine shaft per unit weight of water call H_u

$$H_u = (H_1 - H_2)(1 - \alpha) + \frac{jc}{g}(T_1 - T_2) - (Z_1 - Z_2)$$

$(H_1 - H_2)$ difference in heights of the water columns corresponding to the pressures in the measuring enclosure $= (P_1/w - P_2/w)$

w is the specific weight of water

α is a coefficient, function of H_1 and T_1, to determine the internal energy of the water (Clapeyron's equation).

T_1 and T_1 Temperatures of the water in tailrace and penstock.

j The mechanical equivalent of heat.

C The specific heat of the water at Temperature T_1 and constant pressure.

g The acceleration by gravity.

$Z_1 - Z_2$ Difference in elevation of points of reference of pressures P_1 and P_2

If H is the net head,

Turbine efficiency $= H_u/H$

This efficiency does not include mechanical losses in bearings nor power withdrawn by accessories (governor, lubricating pumps, etc.)

As the temperature in the measuring enclosure is brought to that of the tailrace by reducing the pressure in the enclosure, $T_1 - T_2$ becomes zero and

$$H_u = H_1 (1 - \alpha) + Z$$

in which Z is the difference in elevation of the measuring points.

Thus the procedure used, instead of requiring a precise measurement of a very small difference of temperature, reduces to a determination of the change of internal energy of the water when the pressure is reduced in the measuring enclosure until the temperature there is that of the tailwater. The coefficient varies with temperature and pressure and can be accurately determined. It generally lies between zero and 0.05.

The French engineers do not consider the method applicable for heads less than 100 meters or 325 ft. Numerous tests have been made on several high head plants and the results compared with tests in which the quantity of water was measured by current meters or weirs. In general the efficiency indicated by the Thermometric method differed from that determined by other methods by amounts varying from zero to one per cent. The results secured in three tests are shown in Fig. 7. Five others are shown in Table I.

Comparison of Four Methods

The neglect to treat various other methods of water measurement in test of hydraulic turbines is not intended to relegate them to a lower grade of acceptability. Volumetric and gravimetric measurements, generally considered to be of the highest order of accuracy, are very seldom applicable. The Weir is limited in its application to comparatively small flows. The Pitot tube has been used successfully in many tests. The travelling screen requires the availability of a straight, very uniform canal and, in other cases, experimental coefficients must be available. It might be argued that the rating curve for a current meter is an experimental coefficient but facilities are readily available for rating meters and experience has shown that the rating of horizontal axis meters remains constant. For the Weir also experimental coefficients are required but a great volume of data collected by many investigators has been crystallized in formulas acceptable for properly installed weirs within certain limits of head and other dimensions.

The first three methods briefly described above have been used most frequently for flow measurements in turbine efficiency tests with a very wide range of flow and the fourth has great promise for plants operating under heads of 300 ft. and upward. It has not received wide acceptance as yet, but it possesses certain merits within its range of application not possessed by the other three methods.

In comparing these various methods one must consider the accuracy of the results, the amount and cost of equipment required, the time required for preliminary preparations for a test, the degree of interference with normal operation of the power plant, the time required for the test proper and the time and expense involved in deriving the final results.

With regard to the accuracy of these various methods one can only reach a conclusion by comparing the measurement of the same quantity by two different methods. Table I submits such comparisons from various sources.

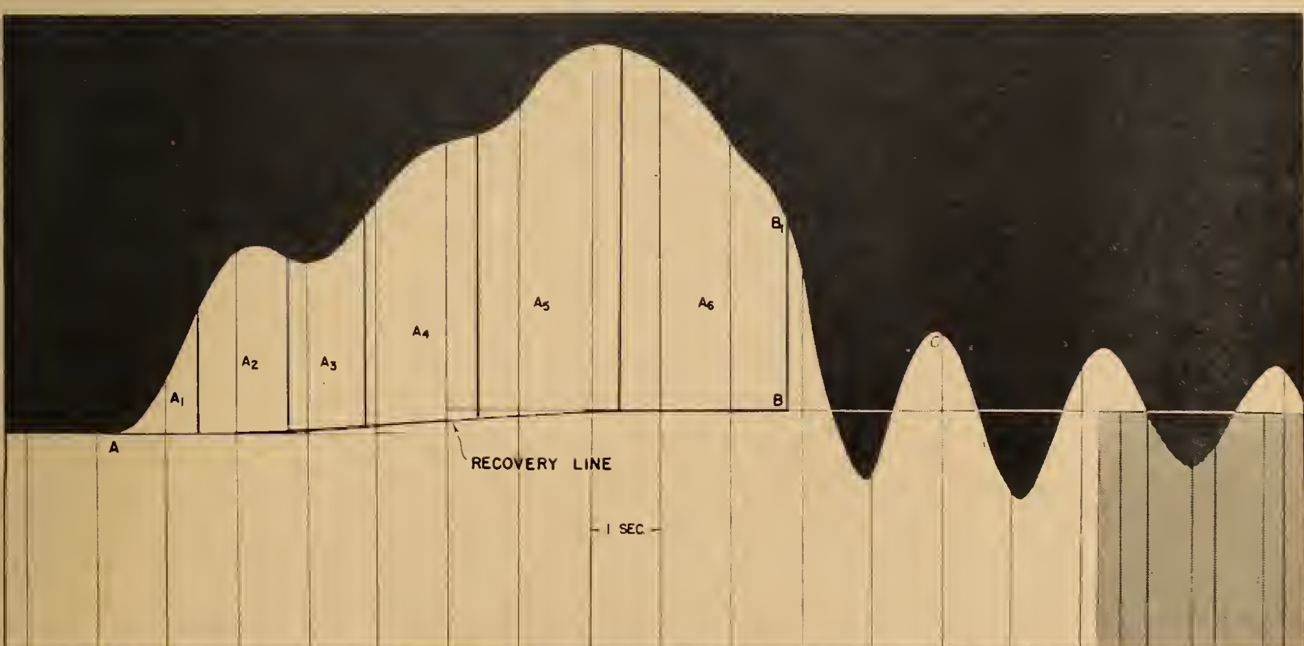
Absolute accuracy of course cannot be claimed in any case. For convenience in this comparison one method in each case has been given a value of 1.000; the figure on the same line under another heading shows the relative quantity as measured by the other method. For example at N.D. de Briancon the weir is marked 1.000 and the Thermometric Method 1.005. This indicates that the Thermometric method gave a discharge half of 1% higher than the weir. It must not be inferred from this that the weir is assumed to be absolutely accurate.

The various methods seldom differ from each other by as much as 1%, in fact agreement is usually much closer than that. All comparisons available have not been shown but of those omitted none was left out because of lack of agreement.

In the final Kinlockleven tests four series of runs are shown, in Series I and II at about 63 cu. ft. per sec. and in Series III and IV at about 75 cu. ft. per sec. The average divergence of current meter and salt velocity in Series I and II is considerably greater than in other cases. This is surprising as in the preliminary tests there at a wider range of flows average divergence was only 0.13 % and maximum in any one run was 1.3%.

The current meter method has been used more widely than any other and in Europe particularly has been developed to a high degree of perfection not only with regard to the instruments and their accessories but also in the standards set for accurate measurement. On this continent the method is thought of as

Fig. 6—Typical Gibson Diagram.



applicable to measurements in open channels or at the intake to a low head plant. In European practice it is used also in penstocks as indicated above even under very high heads.

Reference is made above to the use of movable steel frames to support the meters and bellmouthed structures to improve conditions at the metering section. Manifestly the bellmouth adds to the cost of the test, may be difficult to install and interferes with normal operation of the plant during its installation. The steel frame built to support the meters, sometimes much more elaborate than that illustrated in Fig. 1, also may add to the cost of the test as it is not likely to be applicable, with revision, to tests at other plants.

In current meter measurements in penstocks also special arrangements to support the meters, as illustrated in Fig. 3 and Fig. 4 involve expense additional to the test equipment proper and for their installation interfere with normal operation of the plant although perhaps not for a great length of time.

Criticism has sometimes been levelled at the Gibson method and the Allen Salt Velocity method on the score of special and expensive equipment being required. A comparison of present day costs in two cases may be of interest. A complete Gibson instrument built in 1958 of essentially the same design as Dr. Gibson's original instrument but possessing many minor improvements cost between $9,000 and $10,000.

This included the Gibson instrument, lamp, film drums, glass tubes, steel risers, shipping cases and calibrations. A quotation received about the same time for 12 meters for use in a test of a large plant was $6,084. This included 12 meters, a 14 pen chronograph, clock, meter calibrations and plaster casts of propellors, and shipping cases.

It must be kept in mind that the equipment for both Gibson tests and current meter test will be usable over many years. Two Gibson instruments built forty years ago and used in tests of about 200 turbines are still in use. Minor revisions and replacements have been made from time to time such as new risers and lamps but these have involved expenditures amounting to a small part of their original cost. The same is true of the current meter equipment; some Ott meters purchased by the author 30 years ago are still in service.

The author has no good information regarding the cost of equipment for the Allen Salt velocity method and the Thermometric method but believes it would be less in each case than for the current meters and accessories quoted above.

Table II.

Method	*Weight of Equip. lbs.*	*Installation of Equip. Man Hours*	*Unit out of Service*	*Duration of Measurements*	*Measurements of Discharge*	*Comments on Col. 3*
1	2	3	4	5	6	7
Current Meter	450	20.5			27	Mounting Meters Measurement of pipe
Pitot Tubes	725	28			12	Mounting Pitot tubes Measurement of pipe
Salt Velocity	825	28	About 2 days	9 hrs 15 mins (2 days)	18	Mounting Valves
Salt Titration	1375	23			9	Complete Mounting Sequence

Data are given in Table No. II regarding amount of equipment, preliminary preparation time required for a series of comparative measurements of flow in a 40 in. penstock under a head of about 900 ft.[10]

It should be noted that this was not a test of a turbine but a comparison of measurements of flow by four different methods. The flow was practically constant at about 63 cu. ft. per sec. on the first day and about 75 cu. ft. per sec. on the second. If a turbine test were made covering the full range of capacity of the unit, measurements would probably be at about 25 different rates of flow; the duration of the measurements would be increased somewhat for the current meter and salt velocity measurements and greatly increased for the Pitot tube and salt titration methods. This is because on changing the rate of flow some time must be allowed for flow throughout the system to become stabilized and the duration of a single measurement for the third and fourth methods named.

Special equipment provided in these tests enabled the current meter discharge to be computed for each run in about 15 minutes by means of a hand calculating machine and about five minutes by an electrical calculating machine. Each of the 27 measurements indicated represents two to ten measurements of discharge.

For the Pitot tube a complete set of readings at one rate of flow required about 75 minutes and computation of results about one hour.

For the salt velocity method injections were possible at intervals of one minute and, at one rate of flow, ten separate measurements were possible in ten minutes. Each of the eighteen measurements indicated in Table II represents the result from about 10 salt injections. Evaluation of results appeared to require more time than the corresponding operation for the current meters.

A direct comparison of these results with the Gibson Method is not possible but complete records are available for many tests. One of these in which a single unit rated at 47,000 h.p. under a net head of 133 ft. was tested is selected as a convenient example. Test equipment shipped to the plant weighed 700 lbs. but this did not include electrical instruments for measurement of power output of the unit. Preparatory work required slightly over 1½ days including setting up of Gibson instrument, headwater, tailwater and net head gauges, gate scale and gauges for measurement of rack and penstock losses and preparation of a photographic darkroom. The unit was out of service from 1 p.m. to 5.30 p.m. for measurement of turbine gate leakage, inspection and adjustment of a governor on a Saturday afternoon and was then restored to service until 10 o'clock the next morning. Gibson runs commenced at 10.35 a.m. on Sunday morning, 26 runs were completed at 3.28 p.m. and the unit was restored to normal service at 4 p.m. Thus the unit was out of normal service for ten hours but as these hours were on a Saturday afternoon and Sunday when system load was reduced, and spare capacity was therefore available, the test did not interfere with normal operation of the plant. Preparatory work in this case required somewhat less time than usual, but if more units than one are to be tested in a plant much of the preparatory work would apply to all units.

Corresponding data are not available for the Thermodynamic method but the author would judge from observations of tests that the equipment would be as low in cost, bulk and weight as for a test by current meters, and that preparatory work and interference with normal operation of the generating equipment would be no longer and might even be less than by any of the other methods.

The following comments summarize the conclusions reached by the author regarding these four methods of conducting tests.

1. Under satisfactory conditions for their application all four methods attain the same degree of accuracy.

2. Cost of equipment for a test is considerable in all cases, the current meter method and, possibly, the Thermodynamic method having a slight advantage over the others.

3. Weight and bulk of equipment is appreciable in all cases the current meter method losing its primary advantage if meter frames and supports are taken into account.

4. Time required for preliminary preparations will depend on the individual case under consideration. Table II shows some advantages for the current meter method but in most practical cases it would lose this apparent advantage. For tests at plant intakes and in open canals it might far exceed other methods.

5. The Gibson Method and the Thermodynamic Method probably interfere with normal plant operation to a lesser degree than other methods. This is because with them there may be no interference with normal plant operation during preliminary preparations whereas the current meter and salt velocity methods do so at that time.

6. The time required for a complete test of say 26 runs as in the case of the Gibson test referred to above would be about the same for all methods. If the time required for rating of current meters is taken into account the other three methods would have a distinct advantage.

7. The time and expense for deriving the final results for discharge is probably least with the Salt velocity method. With modern electronic equipment the current meter method might equal it. Without this the Gibson Method and the Current Meter Method would be about equal.

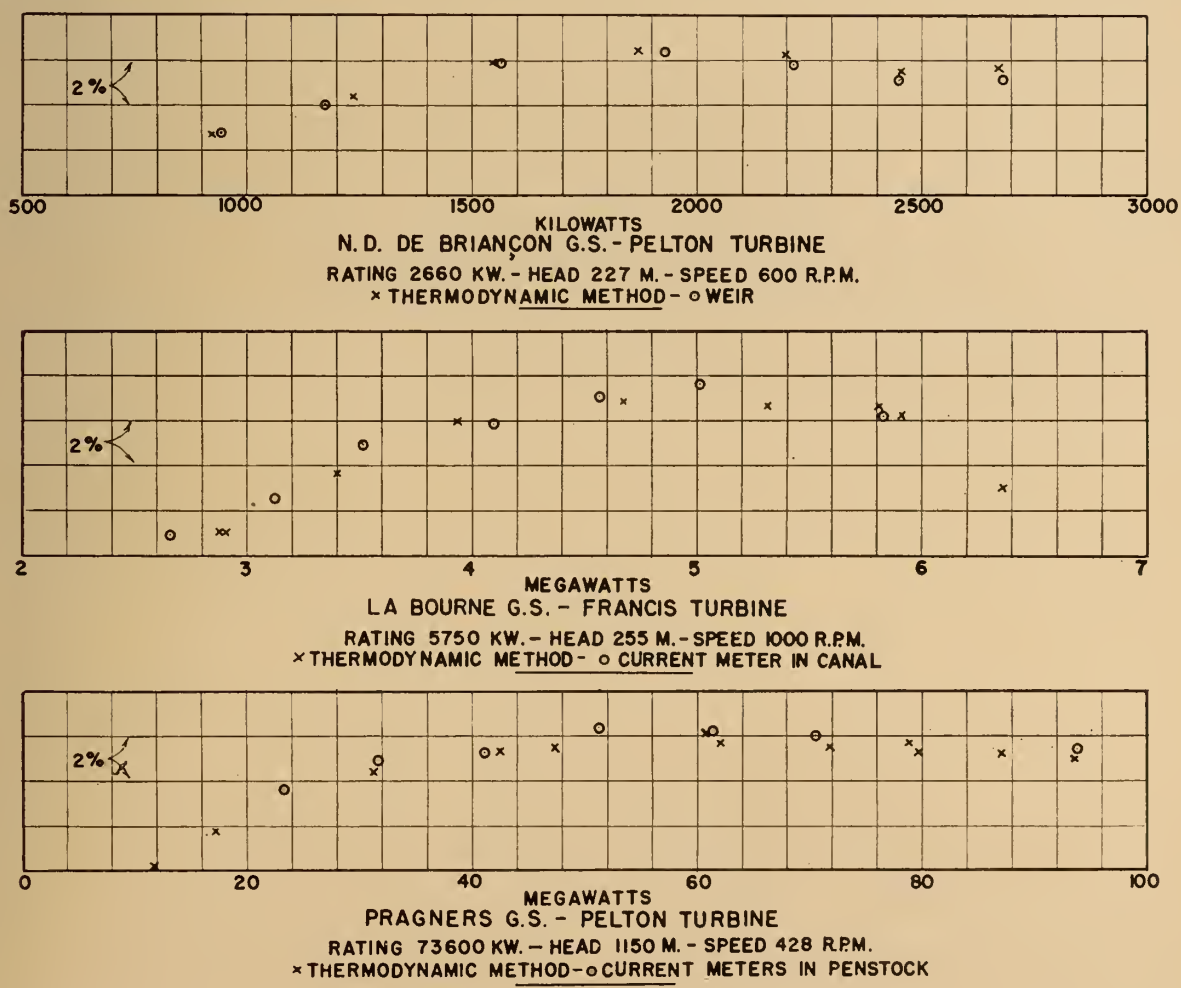
Only brief reference will be made to the two other items in an efficiency test of a turbine namely the head acting on the turbine and the power output. These are measurements that must be made with precision if satisfactory results are to be secured. They are dealt with at some detail in various other articles and test codes. This paper therefore, confines its discussion to the measurement of water passing through the turbine.

The final result sought in a turbine test is a record of capacity and efficiency of the machine along with numerous ancillary results. The flow having been measured, computations to secure this final result are the same no matter what method of water measurement is used. In the author's experience the time required to carry the results to the desired completion generally is as great as to secure the record of flow.

Models of Turbines

Hydraulic turbines have attained their present high efficiency through the immense amount of experiment on turbine runners and settings in laboratories all over the world. Nearly all turbine manufacturers maintain labor-

Fig. 7—Measurements of Turbine Efficiency by Weir and Current Meter compared with measurements by the Thermometric Method.



atories in which tests of small scale models are used to constantly improve their products. A test of a turbine after installation involves considerable expense, may not conform with conditions, names in the contract, as, for example, in the head available at the time of test, and a satisfactory degree of precision in all measurements may be difficult to attain. Tests in the laboratory can be made at more moderate costs, with more complete instrumentation, greater speed, favourable weather conditions and frequently at a range of heads far exceeding the range available in the field. This has led to proposals to substitute laboratory tests of turbine models for field tests of the prototype. It is proposed therefore to discuss laboratory tests and to explore this proposal.

In order to derive the behaviour of the prototype from the results secured from the model it is necessary that between model and prototype it is necessary that there is not only geometric but also dynamic and kinematic similarity. For dynamic and kinematic similarity velocities and forces acting in model and prototype must be similar. In many hydraulic models gravity and inertia are the dominant forces and a relation between model and prototype is readily determined by the Froude number. For hydraulic turbines gravity, inertia and fluid friction are dominant, thus both the Reynolds and Froude numbers apply. In this case as with ship models, there is no simple method of stepping up from model to prototype.

The necessity of having dynamic and kinematic similarity in model and prototype should be stressed. Tests of a turbine model in an open flume, for example, may give misleading results when applied to a prototype with penstock, spiral casing and draft tube, full similarity not being achieved.

Numerous formulas have been suggested for the purpose of stepping up the performance of a turbine model to the prototype. A survey of seventeen of these is presented by Dr. S. P. Hutton,[11] Chief of the Fluid Mechanics Division of The Mechanical Engineering Research Laboratory at East Kilbride, Scotland.

These may be placed in three groups: those in which all losses in the turbine are assumed to behave like friction losses, secondly, those in which the losses are divided into frictional and kinetic components, and thirdly purely empirical formulas. Reference will be made to only a few of these that are in common use although several others are not without merit. Those of Camerer, Staufer and Moody (1935) are in the first of the three groups. Akeret's formula, in common use in France and to a lesser degree in America, is in the second group and the various Moody formulas, with the exception of the one mentioned above, are empirical and therefore in the third group.

Moody in his first formula divided the losses into frictional and kinetic parts but found that for practical purposes it could be used in the simpler form proposed later. A later Moody formula included the effect of head. However, Moody explained at a later date that the exponent of the head term was uncertain and the head term therefore, should be omitted.

The Moody formula of 1942 is the one now in general use and is:

$$\frac{(1 - E)}{(1 - E^1)} = \left(\frac{D^1}{D}\right)^{1/5}$$

where

E is efficiency expressed as a ratio

D is diameter of turbine runner

E^1 and D^1 are corresponding terms for the model

The Ackeret formula somewhat simplified to eliminate new symbols is:

$$\frac{(1 - E)}{(1 - E^1)} = 0.5 + 0.5 \left(\frac{R^1}{R}\right)^{1/5}$$

in which R is the turbine Reynolds number

$$R = \frac{\sqrt{2gH} \cdot D}{\surd}$$

$\surd$ = kinematic viscosity

It seems to be the general consensus that the Moody formula gives an estimate of the efficiency of the prototype that is too high and the Ackeret formula too low at optimum conditions of operation. It is the practice of several turbine builders to use the averages of these two formulas in their estimate of the step up from Model to prototype.[12] From an analysis of the nature of the losses, Dr. Hutton concludes that, at optimum efficiency, about 70% of the losses are frictional and 30% kinetic. Thus the Reynold's number correction should be applied to 70% of the losses and he submits a new formula for Kaplan Turbines which is:

$$\frac{1 - E}{1 - E^1} = 0.3 + 0.7 \left(\frac{R^1}{R}\right)^{1/5}$$

Applying this and the other two formulas to a few specific cases he finds that the new formula agrees with the average of the Moody and Ackeret formulas very well at optimum conditions and for lesser flows than those at optimum conditions but that at larger flows the results are not as satisfactory.

Dr. Hutton in his analysis is dealing with Kaplan turbines and says that it "is asking a lot for one scale formula to be applicable to both Francis and Kaplan Turbines, because the distribution of the losses in the two cases may be quite different." In so far as the Francis Turbine is concerned therefore one must have reservations regarding the accuracy of the results for the prototype derived from tests of a model by any of the step-up formulas. The most widely accepted formulas for this purpose at the present time appear to be the Moody formulas in the form given above, the Ackeret formula or the average of the results from them.

The author is not prepared to accept the test of a model runner, with adjustment of results for dimensions, head etc., as a satisfactory substitute for a field test of the prototype. His reasons are as follows:

(a) The model must have exact geometric similarity to the prototype. This is usually attainable in the Kaplan and fixed blade propellor runner but very difficult with the Francis runner.

(b) Dynamic and kinematic similarity must be attained. This would require a complete installation of model runner, penstock, scrollcase and draft tube something not always readily arranged within the limitations of the laboratory.

(c) There is no step-up formula based on model results that can be relied upon to give exact results at all points for the prototype.

(d) Measurements of water quantities by laboratory methods (Weirs, Venturi meters, etc.) are subject to as great or greater errors as field methods such as the Allen Salt Velocity and Gibson Methods.

(e) Measurement of power output in the laboratory is, he considers, subject to greater errors than measurement of power output in the field where the generator is used as the brake.

(f) The various secondary results from a field test, useful in plant operation, would not be available.

Test Codes

Almost all countries in which the manufacture of hydraulic turbine equipment or its application are of importance have codes governing the conditions under which tests of hydraulic turbine installations must be made. Among these might be mentioned the Swiss, French, Swedish, Italian and American codes. While these are in general agreement as to acceptacle procedure for tests, greater uniformity is desirable. This has become of greater importance as turbine manufacturers from different countries compete for contracts in international trade. Manifestly it is of importance that all should be required to conform to the same conditions.

While their primary purpose is to define acceptable standards for tests they often go far beyond this in suggesting to the test engineer methods of

(Continued on page 80)

BUSINESS TRAINING FOR PROFESSIONAL ENGINEERS[1]

R. J. Bedard, *former editor of "Genie Construction".*

SHOULD engineering schools give their students more training in industrial organization and management, personnel and labor relations, law, and other subjects generally associated with business administration?

The replies to this question are far from unanimous. Some educators and managers argue that the function of an engineering school is to teach engineering. They maintain that industry is the best place to learn about business administration; furthermore, that the pressures on the curricula are such that nothing can be dropped, they say, in order to add more business training in the engineer's curriculum.

To this, many people in education and in management reply that the practice of management is eventually part and parcel of the career of a professional engineer; consequently, they maintain, he should be adequately prepared to shoulder these responsibilities.

There is much evidence that engineers are not happy with the training they have received (or not received) in matters pertaining to industrial management. The survey made by the Corporation of Professional Engineers of Quebec last year has brought this fact into sharp focus. As shown in Table I, less than one half the engineers, and in some cases, less than one quarter, are satisfied with their training in political economy, industrial organization, law, personnel administration, etc.[2]

Should engineering schools give their students more training in business administration? This is no simple question, especially if we keep in mind the pulling and hauling of engineering curricula over the past two decades. The reforms urged recently have suggested that:

1) Engineers should spend a maximum amount of time on the study of the basic principles of physics, chemistry and mathematics;

2) Engineers should be educated as well as trained. In order to give engineering students an education, it has been proposed that they spend at least 20% of their class time on the study of the liberal arts. Needless to say, business subject-matters are not considered to be parts of the "humanistic-social stem" of engineering curricula;

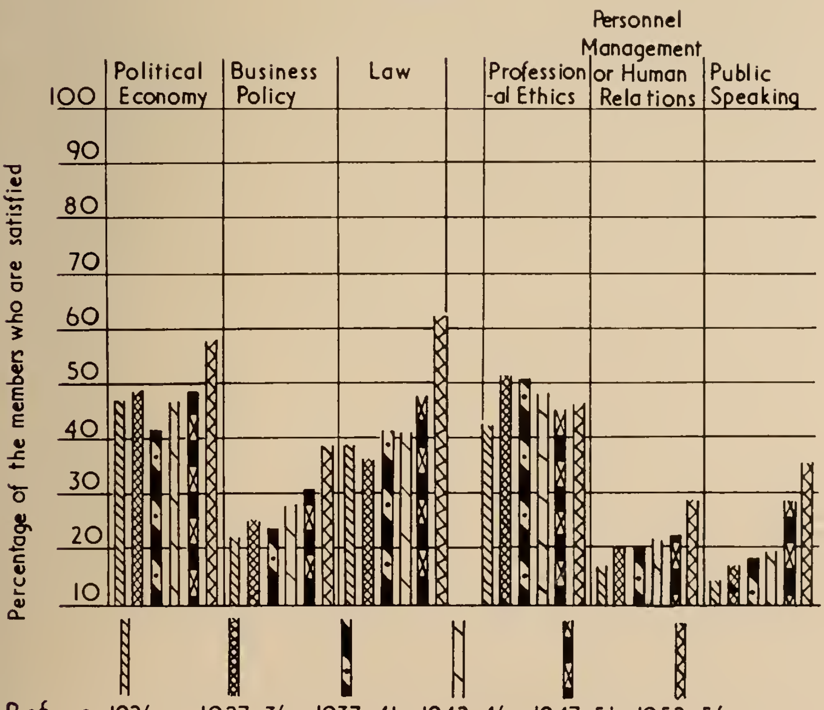
3) Engineers should be "broader," but at the same time the standards of professional competence must be maintained if not raised. Nobody wants "the bridges to collapse, the light to fail, the water to become polluted nor the oysters to become radio-active."

Engineering schools cannot be all things to all men. Choices must be made. To determine what things are the more important, possibly we should try to find out the career patterns of professional engineers.

A survey made by Purdue University among 85 large employers who had a total of 75,565 professional engineers on their payrolls has shown that 41.9% were concerned with research and development, 30.4% were in the actual operation of the business and 27.7% were mostly busy with some human relations aspect of industry.[3]

John B. Rae studied closely the careers of M.I.T. graduates and he found that "nearly half the alumni of M.I.T. have gone into business roles other than that of professional

Table I



engineering."[4] Rae thought his findings were a fair representation of engineers' careers all over the United States.

The fact that a large number of engineers turn managers is in no way exclusive to the U.S.A. In Germany, 36% of the 2,018 graduate executives listed in the directory of directors called "Adressbuch der Direktoren und Aufsichtsräte" hold engineering degrees.[5]

According to the 1957 Survey of the C.P.E.Q., about 65% of the members are employed in executive and supervisory capacities. These figures give a good idea of the career pattern of the professional engineer in Canada, the United States and Germany.

Engineering schools are making every possible effort to give their students the kind of education that will enable them to develop their personal abilities to the limit and at the same time to serve the community as professionals in the best possible way.

The prime concern of the engineering graduate it is expected, will be technology. His curriculum is arranged accordingly. But since a large number of engineers eventually progress into managerial jobs, it is only fair to question what engineering schools are doing for the graduate whose prime function will be management. In other words, are Canadian universities doing an adequate job for the engineer turned manager?

Our engineering schools generally give their students a full course in political economy. To what extent does this course give them a better understanding of industrial operations? It is hard to say. Occasionally, the students are required to pick a full course in accounting or finance or business policy. But this is about all.

Some of our schools of applied science operate an "à la carte" system. Students often take advantage of this to pick law, corporate finance, industrial and labor relations, etc., among their electives.

By any standards the business diet of Canadian engineering graduates is quite weak. When these boys come into industry, management must start teaching them the very elements of the operation of a business. This is often frustrating for the young engineer, and sometimes quite irritating for management. The results of this are well known: a) inadequate growth for the average engineer during the first five years of his professional career; b) frustration and unrest among engineers.

Possibly colleges of technology in Canada could consider giving their pupils a more adequate preparation in this area.

One of our engineering schools is already offering a Business and Engineering course: the School of Applied Science at the University of Toronto. This course is the only one of its kind in the country.

The Business and Engineering option is open to those young men who intend to "get a good technical background for a career in business management." About one fourth of class-time is spent on the study of administrative techniques and problems. Field work plays an important part in the course: the program provides for a minimum of 1,200 hours of practical experience in business or industry as a condition for a Bachelor's degree.

Course IV, as it is known on Varsity campus, is conspicuous by the number of students it attracts each year. On a total registration of 1,985 in 1958-59, one hundred and forty-eight students are taking Engineering and Business Administration.[6]

Indeed we do not suggest for a moment that this is the model on which other Canadian universities should pattern a business training for their students. Although a truly remarkable venture, this is not what we consider to be *the* course.

Over the years, engineering schools have made quite a few successful experiments in the training of their students for eventual managerial responsibilities. It may be worthwhile for our colleges of applied science to draw on this vast pool of experience. Two types of business training are at present offered to engineering students:

A) the horizontal type, that is, business training that attempts to develop broad understanding of administrative problems;

B) the vertical type of training which combines regular engineering instruction with some courses in one particular phase of management or with administrative training for a specific industry. We will now review briefly some of the more effective programs of both types.

The Horizontal Type

1—Massachusetts Institute of Technology a) At M.I.T. the undergraduate course has a duration of four years. The first year is common to all sections. Then the students make a choice of one section among thirty-four.

Sections XVA and XVB (Business and Engineering Administration) offer the students a solid grounding in both engineering and management. The programs of Course XVA and Course XVB are made up of about 50% of technical subject matters (physics, chemistry, maths., drawing, surveying, etc.) and of about 50% of non-technical subject matters ("humanities") and a wide variety of electives related to business administration.

These courses were started in 1914 and ever since have been very popular with Technology students. About 12% of the degrees awarded by M.I.T. since 1920 have been given to people who have picked Business and Engineering Administration courses. During the year 1956-57, a total of 281 students out of a total of 3,656 were registered in these courses.

b) Recent college graduates who have majored in some fields of engineering or natural science can take post-graduate instruction at M.I.T.'s Graduate School of Industrial Management.

The School offers young engineers of outstanding ability a two-year course that entitles them to the Master's degree of Science in Industrial Management.

The purposes of the School are: 1) to assist young men to fit themselves for positions of future business leadership; 2) to study and report on means of increasing the effectiveness of industrial management. "The School is firmly committed to the objective of providing a solid foundation for general management. Students do not concentrate in narrow fields; they don't study skills that can be learned as well or better on the job. Instead, the School concentrates its attention on those areas where learning by practical experience is most difficult."

The foundation subjects studied in the first year fall into four categories: a) those dealing with the environment in which management operates; b) those focusing on the human aspects of administration; c) those devoted to acquiring familiarity with the tools of management (statistics, accounting, etc.); d) those representing preliminary explorations of management functions (production, finance, etc. . . .).

The second-year curriculum includes eight one-semester advanced subjects plus a thesis. Each student picks his own courses; they are generally broadly distributed.

c) The Executive Development Program was inaugurated in 1931 by Prof. Irwin Schell with six students. Since then the E.D.P. has expanded steadily. The Sloan Fellows — as they are known on M.I.T. campus — are young men with ten years or more of successful engineering experience in industry. They are selected on the basis of their promise of growth into major executive responsibilities. Eighteen students are selected among candidates nominated by the top management of a sizeable number of firms, large and small, from all over the United States and from abroad as well.

These young executives spend twelve months at M.I.T. to study in depth the fundamentals that underlie sound management action. Residence in Boston area is compulsory. Since 1953-54, more financial assistance on the part of the Alfred P. Sloan Foundation has enabled M.I.T. to have each year two such groups of eighteen young executives.

During the E.D.P., the Sloan fellows experience a widening of horizons and a deepening of understanding of the environment of industry. When they return to their companies they know more thoroughly how the demands of production, personnel, marketing, financial control, all fit into a total operation.[7] Table III illustrates the makeup of the Program.

Table II
Occupational Pattern of 75,565 Engineers

Degree	(A) New Developments	(B) Operations	(C) Human Relations	Total
B.Sc., B.Eng.	26,541 83.8%	20,058 95.9%	19,489 93.3%	68,086 90.1%
M.Sc., M.Eng.	4,119 13.0%	895 3.9%	1,346 6.4%	6,360 8.4%
D.Sc., D.Eng.	1,016 3.2%	42 0.2%	61 0.29%	1,119 1.5%
	31,696 41.9%	22,993 30.4%	20,896 27.7%	75,565 100%

NEW DEVELOPMENTS: Those who deal primarily with new techniques, ideas or products. This includes research, development, design.

OPERATIONS: Those whose primary function is the operation of existing plants or designs. This would include production, operation, service.

HUMAN RELATIONS: Those who deal principally with the human aspect of technology. This would include production supervision, sales, personnel administration, etc.

2—Carnegie Institute of Technology — A six-million-dollar grant by the Mellon Foundation enabled C.I.T. to create the Graduate School of Industrial Administration in 1949. Since October 1952, the School presents four different programs for the training of engineers in business management.

a) The Master's program. For the students who have had training in engineering or science and who have potential for future industrial leadership. The average age of the students is 28. Nearly all of them have had two or more years of actual experience in industry. The annual intake of students is limited to thirty.

The program is two years in duration. During the first year they study the fundamental principles of marketing, production, personnel, labor relations and finance. The required courses of the second year focus on the formation and integration of policies, integrating the several aspects of management studied during the first two terms, and relating the formation of business policies to the changing world in which modern business exists. Elective courses provide advanced training for each student in the area of management in which he is particularly interested.

b) Carnegie "Tech" offers an engineering course that enables the student to get a B.Appl.Sc. degree in four years; we have just seen that C.I.T. is also offering a two-year program leading to the Master's degree in Industrial Administration.

The College of Engineering and the School of Industrial Administration have started a special program whereby students of outstanding ability may combine the undergraduate degree with the Master's degree in a total of five academic years.

c) In order to train scholars for teaching and research, C.I.T. has inaugurated two doctoral programs related to business management. One is known as the Ph.D. program in Industrial Administration, the other, the Ph.D. program in Industrial Economics. These two doctoral programs do not accept more than ten new students each per year.

d) The Program for Executives is intended for mature business administrators already holding positions of responsibility in industry. The special nine-week programs offered by the School each Spring are intended to provide an opportunity for these executives to study policy formation at the top executive level.

3—Federal Institute of Technology, Zurich — The Federal Institute of Technology started a program of study in administrative techniques and industrial organization (Betriebswissenschaften und Fabrikorganization) in 1936. This course is an adjunct to course IIIA (mechanical engineering) and IIIB (electrical engineering). During the first five terms all the students take the same basic instruction. Then they select a field of study of special interest to them: many students major in engineering administration.

Previous business experience plays a prominent role in these programs. Students must have had at least one year of experience in industry before they are accepted. During their school years they must spend several months in various field work assignments and then write up reports about their observations.

In 1929 Federal "Tech" created a Betriebswissenschaftliches Institut (Institute for Management Research) whose functions are research and the training of administrative engineers. This course is an outstanding example of how business and engineering instruction can be blended together in a highly integrated course. Table IV gives the analysis of the program.

The Vertical Type

1—Stanford's Civil Engineering — Construction Management Program— Every year more civil engineering graduates go to work for contractors and construction firms. Stanford University thought it seemed appropriate to offer courses leading to the Master of Science in Civil Engineering-Construction.

Stanford's graduate construction management program actually began several years ago. Prof. J. Fish, former head of Civil Engineering, was aware that many civil engineers gravitated or were forced into administrative work. It was apparent that these men were badly handicapped because they had no background whatsoever in finance, accounting, personnel, law, and other subjects with which they, as administrators, had to deal. These lessons had to be learned after the men became managers. It was to fill these gaps that prof. Grant developed a graduate program in civil engineering-administration. It combines advanced work in technical subjects with administrative courses offered either by the Engineering School or the Graduate School of Business or the Law School or other departments of the University. A sizeable number of graduate students have now completed this program, while many others have taken some of the courses offered.

The master's program requires 45 or more quarter units which include: 1) a core of mandatory graduate construction and business courses: Construction Administration, Advanced Construction Equipment and Methods, Special Construction Problems, Advanced Engineering Economy, Depreciation of Plant and Equipment. 2) Two required courses in advanced civil engineering: Advanced Foundations Design and Harbor Structures. 3) Elective courses in business and industrial engineering. 4) Elective courses in advanced civil engineering.

Contractors of the San Francisco area have shown much interest in this course. Conversely, the alumni

Table III

The Executive Development Program for Sloan Fellows

PRELIMINARY SURVEY					ANALYSIS IN DEPTH	
June 1957					June 1958	
ORIENTATION WEEK: EIGHT SESSIONS WITH BUSINESS LEADERS	SUMMER TERM	PLANT VISITS AND MANAGEMENT INTERVIEWS: MIDDLE WEST	FALL TERM	VISITS WITH EXECUTIVES: NEW YORK / VISITS TO GOVERNMENT AGENCIES AND POLICY MAKERS: WASHINGTON, D.C.	SPRING TERM	SUMMARY PRESENTATIONS: BY FELLOWS
	Management Series Accounting Production		**Industrial Management Seminars** Meetings with Guests from Industry and Labor Group Discussions		**Industrial Management Seminars** Meetings with Guests From Industry and Labor Group Discussions	
			Management Series Production; Marketing Policy		**Economics and Finance Series** Corporate Finance	
	Economics Series Price Determination National Income Money and Banking Comparison of Economic Systems		**Economics and Finance Series** Fiscal Policy; International Trade		Corporate Tax Problems; Problems of Sizes of Business	
			Labor Series Labor Relations and Public Policy		**Laboratory in Executive Behavior**	
			Principles of Organization; Problems in Administrative Policy		**Management Philosophy**	
					Social Science Current Problems in U.S. Foreign Policy	
	Labor Series Personnel Administration Group Relations Labor Economics		**Problems in Human Relations**		**Current Management Problems**	
			Social Science Series Structure of American Law; Industrial History		**Thesis**	
			Technical Seminars **Guest Scientists**		**Technical Seminars**	
			Local Plant and Management Visits		**Local Plant and Management Visits**	
			Thesis			

"Executive Development Program 1957-1958", the School of Industrial Management, M.I.T., p.8-9.

of the Stanford Civil Engineering-Construction Management Program have proven their worth in the construction industry.

2—Industrial Relations at "Caltech." — California Institute of Technology gives engineering students who so desire a solid background in industrial and labor relations. The Dept. of Industrial Relations was opened at "Caltech." in 1939. Its growth has been phenomenal. The numerous publications of the Department are known throughout the free world.

In the Section of Industrial Relations as in all the other departments of the Institute, research by the staff is a major ingredient of good teaching. Many students take advantage of this high-grade teaching to get acquainted with the personnel and industrial relations problems of a technology-inclined society.

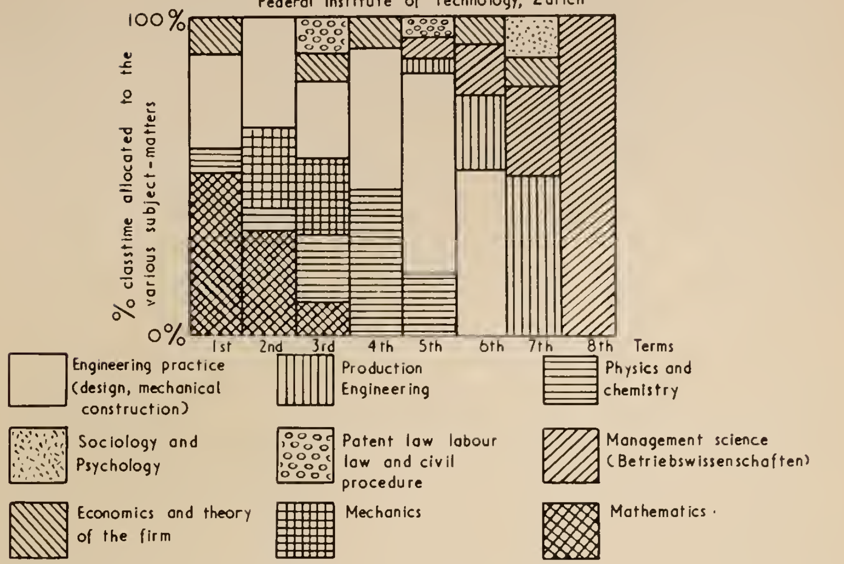
During 1955-56, one hundred and twenty-five students regularly attended classes in labor economics. As a further contribution to the development of professional engineers into managers, the Dept. of Industrial Relations is offering CalTech's alumni seminars and refresher courses dealing with labor relations, personnel selection, and recently, with the management of scientific research.

3—Industrial Engineering at Cornell — Industrial engineering means different things to different people. Quite a few American and foreign universities give instruction in industrial engineering. The Department of Industrial and Engineering Administration of Cornell's School of Mechanical Engineering gives a most interesting and most effective program.

"The Cornell Plan is based upon first developing a sound mechanical engineering program and then integrating with this the necessary business management principles and techniques. A student cannot become a good industrial engineer or administrator unless he is first a good engineer in the true sense of the word. Thus industrial engineering at Cornell is not approached through a general business course with a smattering of engineering or science courses, but rather from a thorough grounding in engineering."[8]

It should be noted here that Cornell is one of the few engineering colleges of the United States to have adopted a five-year course across tho board. The Industrial Engineering course concentrates on fundamental

ENGINEERING ADMINISTRATION COURSE (BETRIEBSINGENIFURWESEN)
Federal Institute of Technology, Zurich



(1) "Eidgenössische Technische Hochschule 1855 1955," Buchverlag der neuen Zurzher Zeitung, Zurich, 1955, p.349

Table IV

concepts rather than on techniques. Its strength lies in the sequence of the subject matters as well as in their integration with the other engineering subjects.

4—British Engineering Schools offer courses geared to the needs of many different audiences — The Dept. of Management Studies of the Polytechnic, London, and the School of Industrial Administration of the Manchester College of Science and Technology, offer a wide variety of courses to engineering and non-engineering personnel.

The latter, for instance, repeats each year no less than seventeen different programs. Space limitations will not allow us to study in detail every one of these programs. A part-time day course and one evening course have been arranged with the co-operation of the Institution of Mechanical Engineers. The "Administration for Chemist" course has also been opened to give chemical engineers an opportunity to become more familiar with management problems.

Among the many other programs by Manchester College of Science and Technology, let us mention "Administration for Works Managers," "Discussion Groups for Foremen," "Certificate Course in Foremanship."

By so doing, the British colleges of applied science perform a most valuable function in the community. They also serve the engineering profession in a most useful way.

We have found in the first part of this study that more business training is a must for the professional engineer. This, we have seen, is necessary in order to enable him to achieve a full measure of personal development. The management of private and public affairs is part of the responsibility to society of one half the engineers. A knowledge of the fundamental principles of management should in some way be part of the engineer's training.

Some colleges of technology are training men for the management of "men" just as well as they do for the management of "things". In Canada, however, this kind of instruction is next to non-existent. As Robert Doherty said a few years ago, "engineers are literally flung into industrial management and other responsibilities where social and economic elements are dominant, and they have to learn to deal with these new responsibilities while on the job and with no fundamental preparation such as he has had in engineering itself."[9]

Then, what should Canadian engineering colleges do to close the gap?

Over the past two decades this question has been hotly debated by both educators and managers.[10] No final answer has yet been found.

To find out in what direction our engineering colleges should move about management training, more research is needed. Possibly our engineering societies should get together with engineering faculties for a thorough re-examination of the problems involved in management education by engineering schools.

At the undergraduate level, it is doubtful whether engineering schools would serve a useful purpose in dropping fundamental scientific courses in order to include more business subject-matters. In my opinion, a more effective use of the time already alloted to business topics could give undergraduates a better basis upon which to build a career in management.

Canadian engineers should have more opportunities for *graduate work* in business administration. Careful consideration should be given to the necessity of creating four departments of management studies in some of our leading engineering schools, one in the Maritimes, one in French Canada, one in Ontario and one in Western Canada.

What type of training should be offered? This is a question each school should answer for itself. One thing is sure — the instruction given by the schools of commerce generally does not fit the needs of the professional engineer.

Post-university studies

In order to train the managers they need, many firms have become educational organizations as well as business enterprises. Personnel development programs have been arranged both inside and outside business. These programs are intended to enable their participants to take over managerial responsibilities. Many engineers have taken these courses which have proven very profitable to them. These management development programs have a big shortcoming however: "Too little and too late," to quote Colonel Urwick.

Management training is most effective when the young man has been practising his career about five years and has tackled business problems. He is not yet overloaded with business or family responsibilities. He has time left to think and to study.

Engineering schools would perform a most useful service for their alumni if they gave them post-university management courses adapted to their needs and previous training.

Some may challenge these views. This article intends to turn the spotlight on the problems of the engineer turned manager. The hope is that people will start thinking about what can be done to give the professional engineer more opportunities to attain ever higher standards of leadership.

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TESTS OF HYDRAULIC TURBINES . . .

(Continued from page 74)

procedure and instrumentation not readily found elsewhere.

There is nearing completion at the present time an International Test Code, the product of Technical Committee 4 of The International Electrotechnical Commission. This, it is hoped, will have general acceptance when completed. At the last meeting of this committee held in Zurich, Switzerland in October 1957 forty-two delegates (three from Canada) were present representing thirteen different countries, a meeting characterized by a most gratifying spirit of co-operation. The products of the labours of earlier plenary sessions and of some eight subcommittees are now in the hands of an editorial committee which will probably report at a meeting to be held in July of this year.

Acknowledgments

The author wishes to acknowledge gratefully the assistance he has had from various sources in the preparation of this paper.

Prof. Leslie J. Hooper reviewed and revised the part of the text dealing with the Allen Salt Velocity Method and supplied other information.

Material available from work with Dr. Normal R. Gibson has been freely drawn upon.

Messrs. M. Remenieras and S. Ferry of Electricite de France and Mr. Pierre Misson of Neyrpic, Grenoble, France supplied data regarding the Thermometric Method.

Data on certain model tests and related matters were made available by Dr. H. S. Van Potter and Mr. R. S. Sproule of the Dominion Engineering Company, Montreal.

Dr. S. P. Hutton of The Mechanical Engineering Research Laboratory, East Kilbride, Scotland supplied material on comparative measurements of water quantities.

Discussions with Prof. Hans Gerber of Zurich, Switzerland and Prof. G. Hutarew of Stuttgart, Germany have been of great value.

Data have also been made available by former associates of the author at the Hydro Electric Power Commission of Ontario, particularly Messrs. A. E. Aeberli, J. B. Bryce and R. A. Walker.

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No. 11
of a Series

INSTRUMENTATION IN INDUSTRY

The Textile Industry

THE TYPES of plant covered in a survey, by questionnaire, of the textile industry in Canada varied quite considerably. The range ran from the manufacturer of surgical dressings through cotton mills and other fabrics manufacturing, to producers of industrial fabrics such as felts and insulating material.

The types of instrument used also vary with the nature of the industry to some extent, but spinning, weaving, and similar processes are generally high-speed mechanical operations that lend themselves to automatic control of such variables as speed, tension, material feed, etc. Most replies indicated the use of measuring, counting, and recording instruments in this field.

Textile finishing (in some cases), bleaching, and dyeing involve liquid-phase and chemical processes. These require liquid-level controls, temperature and, sometimes, pressure recorders and controls. Spray conditioning machines may incorporate electrical control of spray adjustment, according to operating conditions. Squeeze rolls, for calendering or liquid removal from fabrics, may be controlled automatically or manually for roll pressure via hydraulic or electrical systems.

Power Supply

Most textile plants purchase power from outside suppliers, and a slight majority check supply with their own instruments. Some manufacturers have their own steam plants, some do not, according to the need for process steam in the company's operations.

Who Determines Instrument Requirements?

Nearly all replies stated that instrument requirements are determined by company staff. Specification and recommendation of instruments for purchase is generally the responsibility of the engineering, plant or, in a few cases, maintenance department. These departments are also concerned with the choice of supplier, occasionally in co-operation with the purchasing department.

Servicing of Instruments

The servicing of instruments appears to be about equally divided between the plants' own staff and contract work by instrument suppliers. This is understandable, since investment in instruments in some types of plant is only a small part of the total capital cost of mechanical equipment, and does not warrant the full-time services of an instrument maintenance staff.

Rather more than half the plants replying to the questionnaire use some form of preventive maintenance system for their instruments.

Spare Parts Practice

The general practice in keeping a stock of spare parts for instruments is to build up an inventory based on operating experience.

Instrument Specifications

All plants use mainly standard lines of instruments, but there are also a few cases of the development of special types to the manufacturer's own specifications.

All replies stated that instruments are purchased outright.

Capital Investment

Only a small proportion of replies attempted to give a breakdown of capital investment in instruments and their maintenance costs.

Capital investment varied from less than $5,000 to the $25,000 to $100,000 range. Annual maintenance costs appear to be comparatively low, probably of the order of 5 per cent of instrument investment or considerably less.

Where the use of instruments leads to savings in labour, improvements in quality, etc., the period for recovery of initial investment ranged from as little as one year to as much as nine years.

Gross investment in instruments in the textile industry, and the proportion of capital investment it represents within the industry, is low compared with such operations as the electrical power, petroleum and other processing industries.

IN THE DECEMBER ISSUE

INSTRUMENTATION

IN

BUSINESS AND INSTITUTIONAL BUILDINGS

Canadian Developments

A comparison of curricula, scholarship programs and research projects in the Canadian universities of 1959 suggests most decidedly that training engineers for the atomic, space-conscious epoch ahead presents a challenge.

Many questions are unsettled. Should a grounding in the humanities (called a "Junior Matriculation" by many engineering faculties) precede the highly concentrated technical training which modern technology requires? Or should the engineer become a highly qualified specialist in the first three or four years of university and round out his training with elective courses in contingent humanity subjects? How important to him are business administration and economics? Isn't training in use of the English language essential to him?

For us whose work it is to compile engineering information, communication itself is of first importance. This is quite properly not of equal interest to the professional engineer, but his concern with it is a measure of his breadth of outlook. Almost all Canadian universities include at least one year of English in the engineering degree requirements. Some, such as the University of New Brunswick, require two. Electives in the final year in certain cases allow for the possibility of a second year of English training.

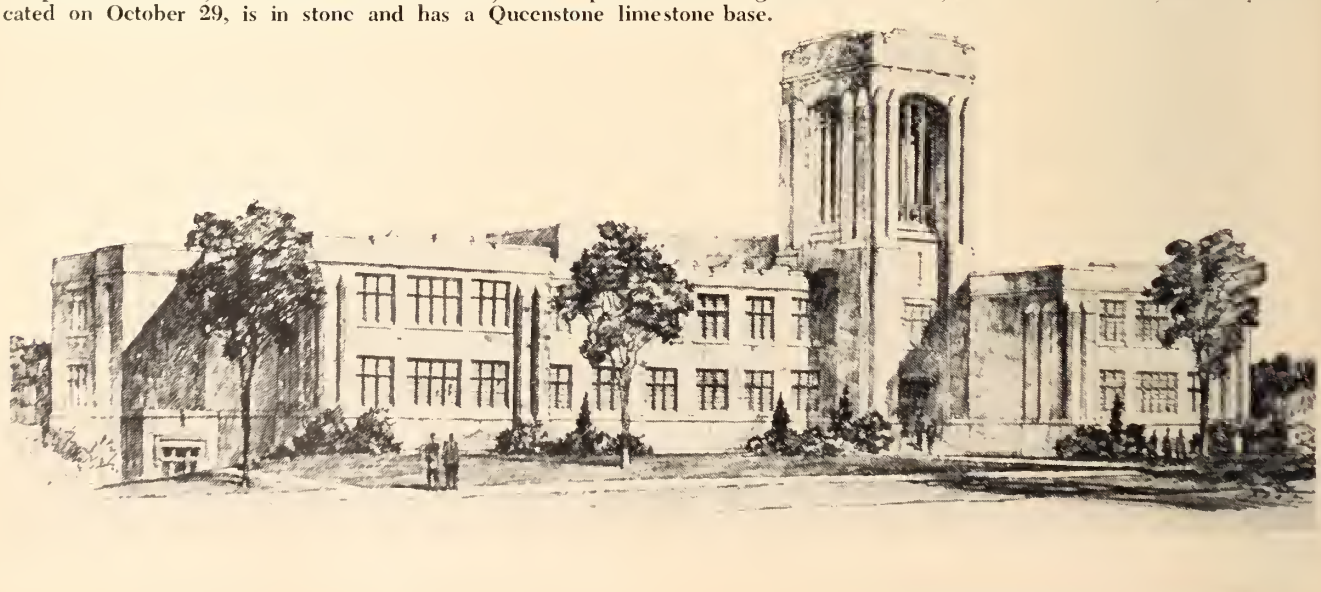
Many of the engineering faculties consider a course in business administration (variously called "industrial management," "business finance," etc.) imperative for the fourth year student, but others do not include such a course even among their electives.

Courses in art and history seem to be making their way into engineering curricula, though they remain in the "elective" bracket in most universities. This whole movement toward liberalizing the engineering program appears the more revolutionary when one considers that humanities programs still have very limited science requirements. Perhaps the engineering faculties will pilot a move by other faculties to give students of the '60s a more truly liberal education.

Enrolment Drop

Registration in first year engineering at the University of Manitoba has fallen off one third from last year. Last year 314 students began the four-year course, while only 217 have enrolled this year. Dean A. E. Macdonald accounted for the drop by various factors—among them stiffer requirements in the faculty (raising the minimum average mark from 50 to 55 per cent) and the fact that thousands of engineers were left jobless when the Arrow was given up. University President H. H. Saunderson blamed the 1957-58 economic slowdown for a slight nationwide drop in engineering registration. He pointed out that the situation is improving—that placing graduates in jobs has been easier this year than in 1958.

The new Engineering Science Building at the University of Western Ontario will provide facilities for courses in chemical, civil, electrical and mechanical engineering. Built at a cost of $1.33 per cu. ft., it contains 110 places for drafting, 125 places in "problem rooms", 300 seats in lecture rooms, and 50 places in reading rooms. The 900,000 cu. ft. structure, officially dedicated on October 29, is in stone and has a Queenstone limestone base.



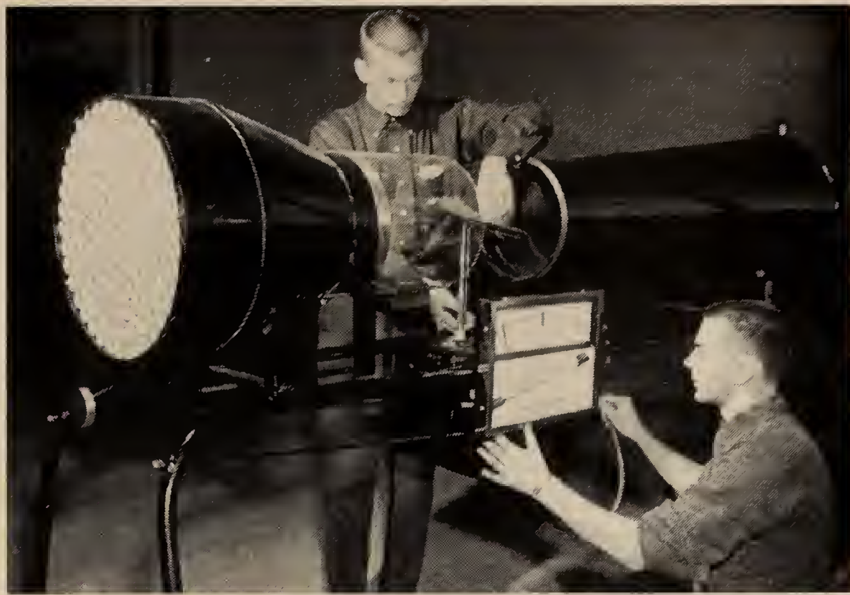
University of Waterloo's Cooperative Course

Two years ago a partnership between industry and education was established when the first 74 students enrolled in the new cooperative engineering course at the University of Waterloo.

This year the total enrolment has come close to the 700 mark and more than 200 companies, representing almost every industry in Canada, are registered with the university to provide off-campus jobs related to engineering.

Classrooms and laboratories are open the year round at Waterloo with half the student body always on campus. Students attend regular classes for three months and then go to assigned jobs in industry to get practical experience for the next three. Although most of the co-operating industries are located in Southern Ontario, students are placed in companies as far away as Regina.

The university's course has been designed in part to attract qualified students who might not otherwise attend university. Because teaching facilities are in operation 12 months of the year, tuition costs are lower than for the traditional course. By working six months of the year, students are able to save from one-half to three-quarters of their tuition and living costs while at Waterloo. Many of the students are former full-time employees of co-operating companies who have been encouraged by their firms to study for an engineering degree.



McMaster curriculum stresses design aspects of engineering and students are required to conduct original research work in their final year. Here engineering students are setting up an experiment using the wind tunnel in McMaster University's new $3½ million engineering building.

Few Show Interest in Toronto Nuclear Course

The $25, 50-lecture course in nuclear engineering being run this term at the University of Toronto has attracted only seven students. The course is intended to outline nuclear energy problems for company executives and technical staff already equipped with an engineering or physics degree. Industrial firms that have not yet contracted to do atomic work apparently feel that they do not want to train executives and technicians at this time.

Shell Merit Fellowship winners from Quebec and Maritime high schools examine a vacuum induction melting and casting unit at Cornell University's School of Chemical and Metallurgical Engineering. The Shell Merit Fellowship six-week seminar at Cornell, sponsored by Shell Oil Co. of Canada Ltd., is designed to help outstanding teachers of high school physics, chemistry and mathematics to keep up with new developments in their fields and with advances in teaching techniques. A similar course for teachers in Western Canada is held at Stanford University.

Saskatchewan Introduces Postgraduate Program

Dr. Arthur Porter, dean of the faculty of engineering at the University of Saskatchewan, finds that a four-year course in engineering is now quite inadequate for training top-grade engineers. A program of honours and post-graduate courses has been instituted at the university this Fall.

The high-speed digital computer is just one of the recent developments which will have a gargantuan effect upon industrial operations. According to Dr. Porter, medical electronics, mechanics, information processing and operational research are the fields in which the engineer must get the most advanced instruction. He also maintains that today's engineering faculties must accommodate a wide range of ability in their students. At Saskatchewan he has introduced honours courses in chemical engineering, engineering physics and geological engineering, with the hope that in another two years still more advanced courses may be added to the curriculum.

The new research work begun at

Saskatchewan has special bearing on the province's engineering demands. Extensive study into materials handling, with special reference to agriculture and the mining and processing of ore bodies, is one of the most important research fields in the university's 1959-60 program.

Essex College Also Introduces Graduate Courses

Essex College, Assumption University of Windsor, Ontario, has announced a series of new postgraduate courses which will lead to an M.A.Sc. degree. The program is planned to accommodate graduate engineers residing within a 50-mile radius. Not more than four, not fewer than two courses must be taken per year according to the new scheme. Each course will be offered in a two-hour period one evening a week during the academic year. The fees for instruction have been set at $100 per course.

Graduate Work in 1958-59 Term

The following data on graduate students in engineering was published in December, 1958, by the Division of Administration and Awards of NRC:

Alberta	
chemical and petroleum	23
civil	32
electrical	4
mining and metallurgy	6
British Columbia	
community planning	8
chemical	10
civil	16
electrical	16
mechanical	4
mining and metallurgy	17
Laval	
chemical	1
electrical	7
mechanical	4
mining and metallurgy	4
civil	4
Manitoba	
community planning	1
civil	8
electrical	12
mechanical	3
McGill	
community planning	2
chemical	10
civil	13
electrical	1
mechanical	19
metallurgy	6
mining	2
Montreal (Ecole Polytechnique)	
civil	8
chemical	1
electrical	1
geological	1
mechanical	14
metallurgy	4
mining	1
New Brunswick	
electrical	2
mechanical	2
Nova Scotia	
chemical	2
civil	5
electrical	1
metallurgy	1
Ottawa	
chemical	3
Queens	
chemical	3
civil	19
electrical	7
mechanical	10
metallurgy	2
Saskatchewan	
chemical	5
civil	1
electrical	5
mechanical	4
Toronto	
aeronautical and aerophysics	31
community planning	1
civil	33
chemical	42
electrical	31
mechanical	27
metallurgy	14

University Research Increasingly Important

Though most research projects carried out in the universities are in the hands of graduate students and professors, there are signs that point to the undergraduate's increasing involvement in the experimental fields.

Civil and electrical engineering vie for first place in amount of research being done in the field. Mechanical follows close on their heels. University staff is commonly involved in government research projects with assistance from graduate students. Undergraduates ultimately gain from such a program because their professors are kept abreast of the most recent developments in their respective fields.

Where Do Bursaries Come From?

In many provinces the provincial government provides bursaries for high-ranking students irrespective of their field of academic pursuit. The federal government also offers bursaries and grants for study and research, but the bulk of these go to graduate students. The greatest single source of scholarship help to Canadian university students comes from industry.

International Nickel Awards Fellowships

Ten post-graduate fellowships have recently been awarded Canadian students in metallurgy, analytical chemistry, geology, physics and mathematics as part of the company's $2,860,000 five-year program to aid higher education in Canada. These fellowships have a maximum tenure of three years and provide an annual stipend of $2,000 with a supporting grant of $500 to the university. Since 1951, thirty-seven such fellowships have been given. Since 1956 an additional 115 four-year scholarships have been established by Inco for outstanding graduates of high schools and preparatory schools. Eighteen of the yearly twenty-five are reserved for students of geology, geophysics, mining, metallurgy, engineering, mathematics and physics.

$1000 in Bursaries From Engineers Wives

The Professional Engineers Wives Association of Ontario presented two first-year engineering students with a $500 bursary each this Fall. Both boys will study at the University of Toronto, one in civil engineering, the other in electrical.

Technical Service Council Places Engineers

Founded to "retain for Canada young engineers with technical and scientific education," the Technical Service Council has been acting since its founding in 1927 as a go-between for Canadian universities and industries. This involves keeping the universities informed of industry's recommendations on engineering and scientific courses and, in turn, helping industries to fill their employment needs.

The council maintains a highly developed office system complete with interviewing facilities, rating techniques and cross-index systems. Current information on employment trends, on changes in supply and demand and on salaries is kept close at hand. Two hundred member companies participate in this non-profit organization.

The Early Post-Graduate Years

The first three years following the undergraduate engineering or science degree are examined in a professional manpower bulletin issued this year by the Department of Labour at Ottawa.* The findings may help in indicating to what degree and how rapidly young professionals are absorbed into employment for which their academic training is intended to prepare and qualify them. Some impression is also given of the graduate's income and geographic mobility at this stage, and it is felt that the analysis may suggest further profitable research in the same field.

Employment

By 1957 almost four-fifths of the respondents to the survey were employed full-time at jobs requiring a technical and scientific background. Such employment was notably higher among engineers than among scientists. In all fields of engineering, well over three-quarters of the graduates had found full-time professional employment, with the single exception of mining engineering where non-technical, non-scientific employment (in most cases supervisory positions are indicated) was high.

The unemployment level, while somewhat higher for scientists than for engineers, was, in the aggregate, very low. Fewer than 1 per cent of the respondents were out of jobs and seeking work.

Approximately 5% of the graduates had acquired non-scientific, non-technical jobs.

The distinction between professional and non-technical and non-scientific employment was made by the respondents themselves. Such a distinction is to a great degree subjective and arbitrary since there are no generally accepted objective criteria. Many positions lie on the borderline (such as technical sales, various supervisory and administrative positions, technical writing and purchasing, to name but a few) because although they may require a certain level of technical competency it is of a rather restricted nature. Such positions can be classified as either technical or non-technical depending on the subjective views of the respondent and the particular characteristics of the job.

In most cases, the positions classified as non-technical and non-scientific by the respondents in this survey included business partnerships or self-employment of a non-professional variety, and in some cases supervisory or administrative work. This was especially true of graduates from engineering and business courses in which about 18% classified their employment as non-professional. A high proportion (14%) of the agriculture graduates also replied that a scientific and technical background was not required in their work; many of these were managing their own farms, a type of work which perhaps does not require technical and scientific training but which nevertheless provides an opportunity for such knowledge to be used quite extensively. Of the mining engineering graduates, 13% were engaged in a non-scientific, non-technical capacity involving, in the main, supervisory work.

Work Experience

Twenty-one per cent of engineers formed two functions in two jobs, compared with only 7% whose functions were the same in both jobs. The same phenomenon is in evidence among the group who held three or more jobs during the three-year period. The percentage values for engineers in order of increasing number of functions are 6, 15, and 18%.

It seems no explanation can be advanced to explain this phenomenon. It may be due to a preference of the employee for a different function at the time he changes jobs or it may reflect the employers' view that experience in one function is prerequisite for the employee to perform a different function satisfactorily. But the report notes evidence that some general hierarchy of functions exists.

Geographic Mobility

It seems that irrespective of the number of jobs held, there is a reluctance or inability to move from the province where the graduate lived or studied.

Nevertheless there was movement. By 1957 11% of the 1954 engineering and science graduates were living in foreign countries, one-half employed and the other half pursuing further

Tables reproduced from Professional Manpower Bulletin No. 5: "EMPLOYMENT OUTLOOK FOR PROFESSIONAL PERSONNEL IN SCIENTIFIC AND TECHNICAL FIELDS 1958-1960", Economics and Research Branch, Department of Labour, Ottawa, February 1959, Price 25 cents, The Queen's Printer, Ottawa, Ont., Canada.

*"The Early Post-graduate Years in the Technical and Scientific Professions in Canada": Bulletin No. 6, April 1959, Economics and Research Branch, Department of Labour, Canada. Price 25 cents, The Queen's Printer, Ottawa, Ont., Canada.

Level of Education, Year of Bachelor Graduation, and Function, 1958
Engineers

Level of Education and Year of Bachelor Graduation	*Number*	*FUNCTION* Research and Development	Designing and Draughting	Testing, Inspection and Laboratory Services	Production, Operation and Maintenance (1)	Supervision, Administrative, Managerial and Executive	Teaching, Instructing, and Extension Work	Sales, Service, Purchasing and Marketing	Consulting	Other(2)
		Per Cent	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
Bachelor's and Bachelor's with some Postgraduate Training										
Before 1918	102	0.9	3.9	1.9	19.6	47.0	2.9	5.8	15.6	1.9
1918-1927	422	2 3	5.4	1.1	10.8	54.4	2.6	7.1	10.6	4.5
1928-37	827	4.4	6.6	1.5	15.9	52.2	1.3	7.3	6.7	3.6
1938-47	1,247	4.4	7.8	1.2	18.4	47.9	0.8	8.8	7.2	3.2
1948-57	3,391	7.3	12.3	2.5	30.0	26.3	0.5	10.6	5.4	4.5
Function not stated	14									
Master's and Doctor's										
Before 1918	5	—	—	—	—	—	—	—	—	—
1918-1927	42	11.9	4.7	—	4.7	47.6	7.1	2.3	16.6	4.7
1928-37	84	11.9	2.3	2.3	14.2	35.7	14.2	3.5	13.0	2.3
1938-1947	144	16.6	3.4	1.3	9.0	34.7	13.8	2.7	8.3	9.7
1948-1957	217	25.3	7.3	2.7	15.6	21.6	7.8	4.6	10.1	4.6
Function not stated	1									
Total	6,496	6.8	9.6	2.0	23.2	36.1	1.6	9.0	6.8	4.2

(1) Includes construction, installation, erection, field exploration, layout and location.
(2) Includes finance, accounting, budgetary control, medical diagnosis, treatment, personnel, industrial relations.

studies. (Of the 122 members of the graduating class who were not Canadian citizens in 1954, by 1957 only 16 were among those who left the country; 65 had acquired Canadian citizenship and 51 were residing in Canada as non-citizens. In all, about 90% of all graduates have remained in Canada after obtaining their bachelor's degree.) In 1954, about 57% of the graduates were residing in Ontario and Quebec, 32% in the Prairie provinces and British Columbia and 9% in the Maritime provinces. Approximately 2% lived in the Canadian territories or foreign countries. In 1957, 60% were living and working in Ontario and Quebec, 24% in the Prairie provinces and British Columbia and 5% in the Maritime provinces. About 11% were residing in the Canadian territories or foreign countries and almost three-quarters of these were in the United States.

The geographical distribution of graduates in 1957 conforms quite closely to the geographical pattern of the net product of manufacturing establishments. In 1954, it rather closely followed the distribution of the total population, which is to be expected as the home address of the students was taken into account rather than their university location.

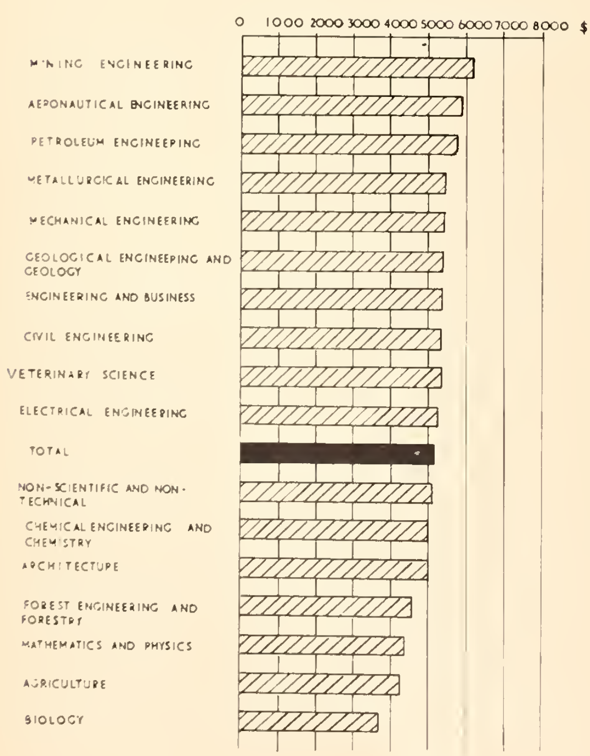
Employment Status by Year of Bachelor Graduation, 1958
Engineers and Scientists

Employment Status by Year of Bachelor Graduation, 1958
Engineers and Scientists

Employment Status by General Field	*Year of Bachelor Graduation* Before 1918	1918-27	1928-37	1938-47	1948-57	*No Degree*	*Total*
ENGINEERS							
Total in labour force	170	610	1,156	1,779	4,352	186	8,253
Working for an employer full-time	110	522	1,015	1,559	4,110	159	7,475
Working for an employer part-time	12	12	15	8	42	2	91
Self-employed full-time	36	67	113	199	190	20	625
Self-employed part-time	11	5	9	8	7	4	44
Unemployed	1	4	4	5	3	1	18
Total not in labour force	107	39	8	6	98	90	348
Students	—	—	—	2	94	3	99
Retired	107	38	7	2	1	86	241
Housewives	—	—	1	1	1	—	3
Other	—	1	—	1	2	1	5
Not stated	—	—	—	—	—	—	—
Total Engineers	277	649	1,164	1,785	4,450	276	8,601
SCIENTISTS							
Total in labour force	57	357	791	1,222	2,624	56	5,107
Working for an employer full-time	45	318	721	1,108	2,411	43	4,646
Working for an employer part-time	4	9	9	15	57	6	100
Self-employed full-time	6	23	52	91	135	5	312
Self-employed part-time	2	3	7	4	12	2	30
Unemployed	—	4	2	4	9	—	19
Total not in labour force	47	22	12	52	301	20	454
Students	1	—	—	7	205	5	218
Retired	46	20	4	—	—	13	83
Housewives	—	2	3	45	90	2	142
Other	—	—	5	—	6	—	11
Not stated	—	—	—	—	—	—	—
Total Scientists	104	379	803	1,274	2,925	76	5,561

Remuneration

The 1954 graduating class obtained their highest salaries in 1957 from industry (median $5,301), with those employed by governments receiving 12% less than in industry (median $4,676), and those in educational institutions receiving 25% less than in industry (median $3,945).



Median salaries in 1957 of the 1954 engineering and science graduates.

There was little salary variation from one type of industry to another, the highest being for those in public utilities with a median salary of $5,588 and the lowest being for those in transportation with $4,964.

In government service, those employed by municipalities received the highest median salary ($5,050) and those in the employ of provincial governments the lowest ($4,370).

In education, graduates employed by universities received a median salary of $4,312 while those employed by high schools received $3,722.

Among engineers frequent change of job was not a factor influencing salary. The highest proportion of all three groups of engineers, (25% of the group with one, 30% of the group with two, and 30% of the group with three or more jobs), all received between $5,000 and $5,500 per annum. At no other salary level have significant advantages accrued to the engineer who was willing to change jobs more frequently.

The period under consideration (1954-1957) was characterized by a steady increase in the Canadian economy's demand for engineers and scientists, with corresponding shortages. The employment experience of

(Continued on page 138)

At the Universities:

Hollister Hall Opened at Cornell

A $2,000,000 building for "instruction and research in civil engineering" was dedicated at Cornell University on October 16. Named for one of America's most prominent engineering educators, L-shaped Hollister Hall contains classrooms and faculty offices in one wing and laboratories and research facilities in the second.

Hollister Hall is the eighth building in Cornell's Engineering Quadrangle. Both a new metallurgical engineering building and a structure for housing two nuclear reactors are proposed for the future. The quadrangle is but one of the accomplishments of Professor Emeritus S. C. Hollister's 22-year term as Dean of the College of Engineering.

Professor Hollister, who resigned last June from the Dean's chair, will have an office in the new building. A former president of the American Society for Engineering Education, he initiated the Cornell five-year program for engineering students, with the double purpose of strengthening technical education for engineers and giving more attention to the humanities.

The new building is the gift of Spencer T. Olin, university trustee.

"Sputnik Fever" charged with Enrolment Decline

The decline in the number of young people now entering engineering schools has been blamed on "Sputnik fever" by Dean Dale R. Corson of Cornell University's College of Engineering. "Sputnik fever" drove many potential engineers in America to study science instead of engineering two years ago, he claims.

In 1958 freshman enrolments were down 11% on the average all over the United States. This year the number of applications was down again.

"There has been a great deal of talk about science in these two years," says Dean Corson. "I think that much of this talk has been misplaced. The satellite and rocket achievements have been engineering achievements, not science achievements, although some of the measurements which have been made with the satellites have scientific interest."

Speaking on engineering curricula, Dean Corson pointed to the dilemma now facing engineering educators: two entirely different curricula are needed. On one hand, the electrical engineer cannot build a super-sensitive receiver for radio waves using the latest developments in solid-state physics unless he understands the physics involved; on the other, the country needs engineers who are going into manufacturing operations, management and numerous other equally important areas which do not require so much scientific training.

The answer, he finds, lies in a "dual-path approach". Beginning in the third year, the engineering student must choose whether he will go in a heavy mathematics-physics direction or take a more normal engineering course.

Harvard and M.I.T. Receive Grants to Study Fusion Power and Space

With a $300,000 grant from the National Science Foundation, Harvard University, Cambridge, Mass., has launched a research project on the behaviour of gases at high temperatures. The study will bear on problems of space travel and atomic power and may even help to explain the workings of the stars.

Massachusetts Institute of Technology (M.I.T.), also at Cambridge, Mass., has received $500,000 from the

Hollister Hall, Cornell University

National Science Foundation for a similar, but separate, study into fusion power, space and space craft.

Nearly a hundred people will be researching in this crucial new field of science, thus establishing Cambridge as one of the world's leading centers for research into power and space. The staffs of the two universities plan a regular interchange of information about their work.

Research at Harvard will be conducted in the High Temperature Gas Dynamics Project under the direction of Dr. Howard W. Emmons and Professor Gordon McKay. The M.I.T. program will be carried on in the Plasma Dynamics Program, headed by Dr. William P. Allis.

"Gas dynamics" and "plasma dynamics" include the study of ionized gases (or plasmas) such as exist in the upper atmosphere of the earth and can be produced in the laboratory. In their most familiar form, they exist in fluorescent light tubes and in the sun where ionized hydrogen atoms fuse giving off enormous amounts of light, heat and other radiations.

In recent years scientists throughout the world have been making concentrated efforts to devise ways by which the fusion reaction (such as takes place in the sun and in hydrogen bombs) can be achieved under controlled conditions. If successful, these studies will give a method of converting unlimited quantities of deuterium (a form of hydrogen in sea water) into power.

The M.I.T. and Harvard researchers do not propose to build elaborate apparatus to produce the fusion reaction. They will concern themselves with fundamental scientific research to learn more about basic principles. Their studies should lead to information about subjects as varied as fusion power, propulsion of space vehicles, entry and re-entry of space vehicles, communication through space, combustion, transformation of energy between mechanical and electrical forces, and astrophysics.

Gulf Oil Donates $1,000 to Colorado School of Mines

The Gulf Oil Corporation has contributed $1,000 to the Colorado School of Mines Foundation, Inc. Dr. John Vanderwilt, president of the that the money will be used as an assistance grant in the petroleum en- mineral engineering college, states gineering department of the School of Mines.

Gulf Oil contributed three-quarters of a million dollars to educational institutions in 1958 and thus far in 1959 has given an additional $170,000 to institutions throughout the U.S.

Doctor of Science in Industrial Health Degree

The Institute of Industrial Health at the University of Cincinnati is offering graduate training for professional personnel in the field of environmental hygiene — industrial hygiene, air pollution, industrial wastes, and industrial toxicology. The professional training is provided for graduates of approved schools of engineering or science.

The three-year course of instruction leading to the degree of Doctor of Science in Industrial Health will comprise two years of intensive academic study and a third devoted to preparation of a thesis.

A limited number of fellowship stipends is available to qualified candidates. Inquiries should be made to the Institute of Industrial Health, College of Medicine, Eden and Bethesda Avenues, Cincinnati 19, Ohio.

On Education:

U.S.S.R. Gives Superior Program Of Secondary School Mathematics

More Russian students take secondary school mathematics than Americans. In general, they spend more time in class studying advanced mathematical disciplines and cover these fields in greater depth than do North American students. So says Bruce Vogeli, a University of Michigan graduate student in a doctoral dissertation just presented to the university. According to authorities, this is one of the most thorough analyses of Soviet source materials for secondary school mathematics ever made in the U.S.

The best American high school programs in mathematics surpass the standard Soviet program. The U.S. is ahead of Russia in modernizing its mathematics courses and has done a better job of developing different types of mathematics programs for its students.

Although Vogeli believes the standard Soviet secondary mathematics program is better than the average American high school program, he asserts that it is inferior to programs in several of the European countries.

Humanistic Education only for Minority

Really humanistic education is suitable only for a minority, Rene Poirier of the Institut de France, Paris, stated recently at the International Council for Philosophy and Humanistic Studies at the University of Michigan.

"The increased independence of pupils toward teachers as well as parents makes it necessary to consider more what interests them and appears profitable to them — in general, studies which will open the door to an advantageous career." Teaching of the mathematical and formal sciences should begin early, according to M. Poirier, and not wait to be tacked on as a postscript to general humanistic training.

Training Atomic Scientists

The shortage of atomic scientists and technicians can not be solved by a crash program designed to turn out pure specialists. The responsibilities of atomic energy workers and the need for ingenuity, initiative, intelligence, and imagination in the field make a broad general education, founded on a solid classical training in physics and chemistry, essential to the specialist.

These are the conclusions of eighty scientists from forty different countries who attended the international seminar on problems of training specialists in the peaceful uses of atomic energy held at the French Center for Nuclear Research at Saclay, 20 miles out of Paris. The seminar was sponsored jointly by the International Atomic Energy Agency and the United Nations Educational, Scientific and Cultural Organization.

Universities face a singular problem in trying to train specialists in the peaceful uses of atomic energy—a field which did not even exist twenty years ago and one in which what is revolutionary today may be obsolete tomorrow. Professors trained classically themselves in formal chemistry and physics find it necessary to get new knowledge rapidly; universities must equip themselves with new laboratory facilities.

The conclusions drawn from the assembled scientists at Saclay were essentially three: universities must work closely with nuclear research centers in training students, if only for financial reasons; the study of nuclear sciences should not be started too early—specialized courses should appear in the secondary school curriculum but only after a solid training in standard physics and chemistry; and international organizations should play a healthy part in solving these educational problems, making two-to-three-year fellowships available for scientists from countries where atomic research is not yet well developed.

Reorganization in the Soviet Union

The twenty-first Communist Party Congress of the U.S.S.R. has defined a seven-year public education program. The following comments on the new program by Yevgeni Afanasenko, Minister of Public Education of the Russian Federation, are quoted from Soviet News Bulletin.

More is demanded today of the Soviet school system. It must overcome a certain gap which heretofore separated it from actual life, and it must train the pupils in a spirit of devotion to socially useful work, to productive labour.

The public education departments, in concert with local organizations and the public, have classified the schools, deciding to which type each one should belong: eight-year, night school (with shifts, or seasonal or correspondence), secondary general educational or secondary general educational polytechnical labour school with production training.

In keeping with the new law compulsory education in the U.S.S.R. is extended by one year to a total of eight years. The basic type of general educational schools will be the eight-year school for all children from the age of seven to fifteen or sixteen. In the eight-year general educational labour school the pupils will learn the fundamentals of science: Russian, mathematics, history, physics, foreign language and geography. Labour training will occupy a conspicuous place in the curriculum, and so will the study of singing, drawing, music, physical culture, and so forth. From the first year the pupils will be taught certain easy work. The boys and girls who are preparing for their future activities will attend practical production courses at the school workshops and plots of land, then in factory and mills, in collective and state farms, and in agricultural machinery repair shops.

The rural districts which heretofore had only elementary four year schools from now on will have eight-year establishments. There will also be boarding schools and hostels. Transportation facilities will be provided for pupils who live far from the school. Steps are being taken so that the children may get their meals at school.

The reorganization provides for the extension of secondary education everywhere; it can be received without stopping work (in shift, night, and seasonal schools), or by stopping work and enrolling at secondary general educational labour polytechnical schools whose pupils will receive production training, and also in technical schools and other specialized secondary educational establishments.

With the help of school teachers and parents the Academy of Pedagogical Sciences and the Ministry of Public Education of the Russian Federation have prepared draft statutes for all types of schools, as well as draft curricula for the new schools and programs for every subject. These documents are being discussed in the schools, in the *Uchitleskaya Gazeta (The Schoolteacher's Gazette)*, and in specialized publications.

Much is being done to expand the number of boarding schools. In line with the decisions adopted at the 21st Party Congress, boarding schools with accommodations for 250,000 pupils will be opened for the next school year in the Russian Federation alone (as against 83,000 boarding-school pupils in 1958-59). Facilities are provided in all the boarding schools so that the pupils will receive an all-round general polytechnical education, esthetical and physical upbringing, and training in socially useful work.

To meet the new requirements of the schools the output of special equipment for them is to be vastly expanded.

The Ministry of Public Education and the Academy of Pedagogical Sciences of the Russian Federation have worked out new curricula for the higher pedagogical educational establishments. Henceforward the students of higher pedagogical schools will have to go through good practical training in factories and collective farms, to get first-hand information on the functioning of schools, and acquire some skills in the field of the arts (singing, music, drawing), so that they may be in a position to combine their duties at school with extra-curricular educational work, and in conducting study circles for the pupils.

The Commonwealth Scholarship Plan

The following is an extract from a speech delivered to the opening session of the Commonwealth Education Conference, which met at Oxford from July 15-29, by Mr. George Drew, Canadian High Commissioner to the United Kingdom and Leader of the Canadian Delegation to the Conference.

Our plans, it seems to me, should be an expression of our belief in freedom. As we seek an answer to this fundamental question, "what do we mean by Education?" I venture to suggest that all universities today should ask themselves three questions.

(1) Is not the most important problem for the world today a moral and a spiritual one? On the material side we are doing very well and we shall do still better and expand it. Our real weakness and the real division between the totalitarian state and the free society lies in the other field.

(2) What are the universities going to do to cure this weakness, whose existence they cannot possibly deny?

(3) Having regard to the fact that our future will be so largely shaped by the thoughts implanted in the universities, ought anyone to be allowed to pass through a university without thinking about this problem?

Certainly there are no easy answers to these questions. But are the answers so difficult as we sometimes seem to think?

If our universities really regarded this as an urgent and serious problem, it could be solved tomorrow. We are dealing with far more complex questions in the mysterious realm of nuclear physics. People who have unlocked the mysteries of the universe by their combined thought and action surely need not be dismayed by this relatively simple task.

Month to Month

ENGINEERS CONFEDERATION COMMISSION

As authorized by the Canadian Council of Professional Engineers and the Engineering Institute of Canada, the Engineers Confederation Commission has been appointed, and held its first plenary meeting in Toronto on October 18, 1959.

Members of the Commission are:

Chairman: John H. Fox, Toronto, Ontario.

Vice-Chairman: George M. Dick, Sherbrooke, Quebec.

Alberta: J. McMillan, J. G. Dale.

British Columbia: W. K. Gwyer, F. A. Forward.

Manitoba: T. E. Storey, N. S. Bubbis.

New Brunswick: T. C. Higginson, James O. Dineen.

Newfoundland: J. B. Angel.

Nova Scotia: J. Hoogstraten, G. F. Bennett.

Ontario: T. Foulkes, D. D. Whitson, C. T. Carson, L. D. Dougan.

Prince Edward Is: W. R. Brennan.

Quebec: E. D. Gray-Donald, J. E. L. Roy, H. Gaudefroy, H. Cimon.

Saskatchewan: J. C. Traynor, J. B. Mantle.

Yukon: E. W. King.

All provinces were represented with all but three of the Commission members present.

Mr. D. O. Turnbull, President of the C.C.P.E., and Mr. J. J. Hanna, President of the E.I.C., were present and addressed the meeting. They stressed the importance and urgency of its task, and each of them expressed the hope that a final report would be forthcoming in time for consideration at the annual meetings of the two bodies in 1961.

To facilitate its work, the Commission was divided into committees or task groups, each charged with the responsibility of preparing detailed recommendations to the Commission, regarding important aspects of the Commission's work.

These committees are:

Committee on Charter—To draft a complete charter using the E.I.C. charter as a basis if possible.
Chairman: J. G. Dale, Alberta.
Vice-Chairman: F. A. Forward, British Columbia.
T. E. Storey, Manitoba.
J. C. Traynor, Saskatchewan.

Committee on By-Laws—To draft all necessary by-laws assuring that these are consistent with the Charter.
Chairman: H. Gaudefroy, Quebec.
Vice-Chairman: C. T. Carson, Ontario.
T. Foulkes, Ontario.
J. E. Leo Roy, Quebec.
L. D. Dougan, Ontario.

Committee on Administration—To spell-out the broad lines of how the new National Body will be administered.
Chairman: T. Foulkes, Ontario.
Vice-Chairman: L. D. Dougan, Ontario.
J. E. Leo Roy, Quebec.
D. D. Whitson, Ontario.
H. Cimon, Quebec.

Committee on Finance—To work out the details of how the new body will be financed, in co-operation with the Committee on Administration.
Chairman: E. D. Gray-Donald, Quebec.
Vice-Chairman: C. T. Carson, Ontario.
T. C. Higginson, New Brunswick.
J. O. Dineen, New Brunswick.
J. S. Bubbis, Manitoba.

Committee on Branches—To determine how the branches will be formed, financed, operated, etc., and their relationship with the National Body and the Provincial Associations.
Chairman: W. K. Gwyer, British Columbia.
N. S. Bubbis, Manitoba.
J. McMillan, Alberta.
E. W. King, Yukon.

Committee on Other Societies—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.
Membership of this Committee will be determined later.

Committee on Services—To outline the various services to be performed by the new National Body.
Chairman: J. B. Mantle, Saskatchewan.
J. McMillan, Alberta.
F. A. Forward, British Columbia.
T. E. Storey, Manitoba.
J. Hoogstraten, Nova Scotia.

Committee on Relationship with the Provincial Associations—To establish the relationship between the new National Body and the Provincial Associations.
Chairman: J. Hoogstraten, Nova Scotia.
G. F. Bennett, Nova Scotia.
J. B. Angel, Newfoundland.
W. R. Brennan, P.E.I.

(Left to right): J. J. Hanna, president, E.I.C.; J. H. Fox, chairman, Engineers Confederation Commission; D. O. Turnbull, president, C.C.P.E.; and G. M. Dick, vice chairman, Engineers Confederation Commission.

Back Row (left to right): F. A. Forward, E. W. King, W. R. Brennan, J. G. Dale, D. O. Turnbull, G. M. Dick, J. H. Fox, J. J. Hanna, L. Nadeau, G. T. Page, J. B. Angel, D. D. Whitson, T. Foulkes, J. E. L. Roy, E. D. Gray-Donald; front row (left to right): J. B. Mantle, J. O. Dineen, T. C. Higginson, L. D. Dougan, J. Hoogstraten, J. C. Traynor, H. Gaudefroy, C. T. Carson, J. McMillan, N. S. Bubbis, and T. E. Storey.

Co-ordinating Committee—To co-ordinate the work of the Committees and to establish the details of implementation of the decisions of the Commission.

Chairman: Chairman of the Commission.
Vice-Chairman: Vice-Chairman of the Commission.
Members: Chairmen or Vice-Chairmen of all committees.

The Chairman and Vice-Chairman are ex-officio members of all committees.

In the interest of convenience and the practicability of holding meetings that would otherwise require extensive time and travel, geographical consideration was an important factor in the selection of committee members.

The Co-ordinating Committee is charged with the special responsibility of ensuring that there is a maximum of liaison and a minimum of overlapping in the work of the individual committees.

Following the plenary meeting of the Commission, each committee had a preliminary meeting to lay plans for the implementation of the program.

The secretariat of the Commission is shared by Mr. Leo M. Nadeau, Executive Secretary of the Canadian Council of Professional Engineers, and Mr. Garnet T. Page, General Secretary of the Engineering Institute of Canada.

As the work of the Commission progresses, further reports will be made. However, it will undoubtedly require several months of committee work before tangible results begin to appear.

A.E.C.L. Reactor School

Atomic Energy of Canada has announced plans to open the Chalk River Reactor School on February 1, 1960. Applicants for this first 12-week course must have their forms in to the Secretary, Chalk River Reactor School by November 15 so that the twelve successful candidates can be notified by December 1.

Candidates for the school must have a university degree in physics, engineering physics, chemistry, metallurgy, or engineering.

The course, taught by senior company executives and members of the staffs of the various A.E.C.L. divisions in Toronto, Ottawa and Chalk River, will give students the basic instruction necessary for a thorough understanding of the design, construction and operation of nuclear reactors.

Set up in response to the wide interest shown in atomic power systems being developed in Canada, the course will be particularly concerned with power reactors moderated with heavy water and fuelled with natural uranium (such as the NPD station under construction at Rolphton and CANDU projected for a site north of Kincardine, Ontario).

NBC-TV Presents Chemistry Course

NBC television is producing a two-semester college-level chemistry course in cooperation with the American Chemical Society and The American Association of Colleges for Teacher Education.

Monday through Friday, from 6:30 to 7 a.m., Professor John F. Baxter, head of the General Chemistry Division at the University of Florida, does a lecture-demonstration on fundamental principles of modern chemistry.

Last year NBC initiated "Continental Classroom" with an eight-month course in Atomic Age Physics which won unprecedented honors. This year some 300 universities have agreed to offer the course for college credit.

Prentice-Hall, Inc., Englewood Cliffs, N.J., has published both the textbook and study guide (entitled *Modern Chemistry*), written by Dr. Baxter and Dr. Luke E. Steiner of Oberlin College to accompany the televised course.

Financial backing for the "Continental Classroom" course is being provided by the Ford Foundation and ten leading industries.

University of Toronto Interviews with Graduates

Interviews for permanent employment of graduates from the Faculty of Applied Science and Engineering at the University of Toronto will be held on January 21, 22 and 23, 1960.

The university requests that information on jobs available be supplied by employers to each department concerned and to the Placement Service office.

Engineering departments at the university include: aeronautical, architecture, chemical, civil, electrical, engineering physics, geological science, geophysics, industrial, mechanical, metallurgical and mining.

Seventy-three Engineers Out of Touch

The Records Department at E.I.C. headquarters has been searching in vain to locate the following seventy-three members. Current addresses, sent to the Engineering Institute of Canada, 2050 Mansfield Street, Montreal, P.Q., will be heartily welcomed.

Members

Andretsch, Richard F., Ohio, U.S.A.
Gregory, Peter G., Ottawa, Ont.
Hussey, C. H., Toronto, Ont.

(Continued on page 118)

Personals

Alexander Watson, M.E.I.C., director of ship construction and supply of the Department of Transport, has been appointed chairman of the Canadian Maritime Commission by Transport Minister Hees.

R. H. Findlay, M.E.I.C. (Royal Technical College '09), consulting mechanical engineer with the Montreal Branch of the Dominion Bridge Company, has retired after 48 years with the company.

H. William Tate, M.E.I.C. (Toronto '10) has retired from the presidency of De Leuw, Cather & Company of Canada Limited, Consulting Professional Engineers, Toronto and Ottawa, and becomes chairman of the board. Leslie W. Pillar, M.E.I.C. succeeds Mr. Tate in the presidency.

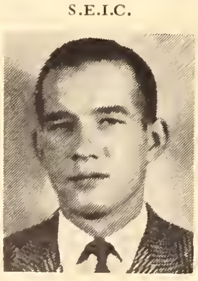
M. Barry Watson, M.E.I.C. (Toronto '10), formerly registrar of the Ontario Association of Professional Engineers and secretary-treasurer of the Dominion (now Canadian) Council of Professional Engineers, has retired from practice to live in Mexico.

R. A. Emerson, M.E.I.C. (Manitoba '30), vice-president of the Canadian Pacific Railway Company, has been made a Commander Brother of the Order of the St. John of Jerusalem by Governor-General George Vanier at Government House, Ottawa.

R. C. McMordie, M.E.I.C. (Toronto '30), has become manager of engineering operations and chairman of the B.C. Power Commission's senior staff executive committee. He is thus the principal engineering officer of the commission, responsible for all engineering and for the production of power.

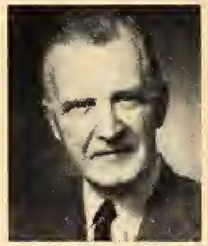
John F. Benjafield, M.E.I.C. (Queen's '33) has been appointed assistant district manager, London District, The Foundation Company of Ontario Limited.

Yvon Jobin
Jr.E.I.C.



Paul R. Ukrainety,
S.E.I.C.

Alexander Watson,
M.E.I.C.



R. H. Findlay,
M.E.I.C.

A. W. Tobber,
M.E.I.C.

Leonard E. Gads,
M.E.I.C.

Andrzej S. Dromlewicz, M.E.I.C., has been made district engineer, Calgary District, The Foundation Company of Canada Limited.

A. W. Tobber, M.E.I.C. (Danzig '34), formerly chief engineer and works manager of Harrington Tool & Die Co. Limited, has been appointed vice-president in charge of engineering and manufacturing.

Leonard E. Gads, M.E.I.C. (Alberta '39), secretary of the faculty of engineering at the University of Alberta since 1946, has been appointed associate dean of the faculty.

A. J. G. Leighton, M.E.I.C. (Saskatchewan '42), has been named director of engineering of the B.C. Power Commission. P. J. Croft, M.E.I.C., is the new director of planning.

V. Douglas Thierman, M.E.I.C. (Saskatchewan '48) has been elected a director of Haddin, Davis & Brown (Alberta) Limited. He is manager for the firm in Edmonton.

H. W. Beekett, M.E.I.C. (Saskatchewan '48) has been appointed construction engineer III for The Consolidated Mining and Smelting Company, Calgary.

D. L. Fuller, M.E.I.C. (Saskatchewan '49) is the new operations manager of Producers Pipelines Ltd., Regina.

C. H. Johnson JR.E.I.C. (Manitoba '49) has been appointed a technical sales representative for petroleum chemicals by Du Pont of Canada Limited. With headquarters in Montreal, he will cover Quebec and the Maritimes.

S. F. Lee, M.E.I.C. (Saskatchewan '50) has become chief engineer of Saskatchewan Government Telephones, Regina.

Yvon Jobin, JR.E.I.C. (Laval '52) is the new superintending engineer in the System Operation, Regional Operation Division of Hydro-Quebec.

Laurie A. Coles, M.E.I.C. (New Brunswick '54), formerly chief engineer for M. F. Schurman Company Limited, has established the firm of Laurie A. Coles and Associates to provide consulting engineering and architectural services in Charlottetown and Summerside, Prince Edward Island.

Marc M. J. Chagnon, JR.E.I.C., (McGill '57) who has been working with the CNR, Montreal has been awarded an Athlone fellowship for two years of post graduate training in the United Kingdom.

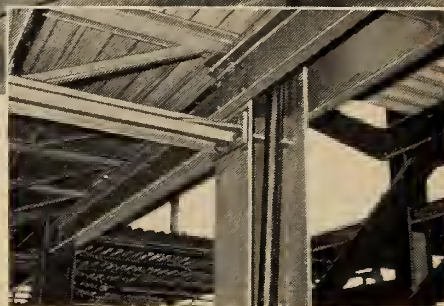
Pierre Fortier, JR.E.I.C. (Ecole Polytechnique '57) has begun work as an analytical engineer with Pratt & Whitney Aircraft Company (Longeuil) after spending two years in England, at the Imperial College of Science and Technology, on an Athlone Fellowship.

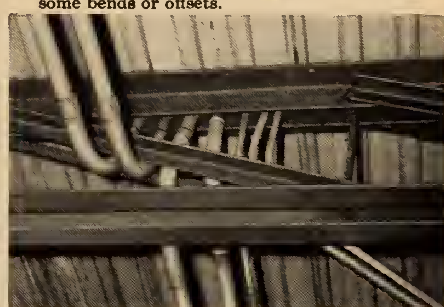
Paul R. Ukrainety, S.E.I.C. (Saskatchewan '57) has returned from a two-year Athlone Fellowship at Bristol, England, working with the Bristol Aeroplane Company Limited, and will begin work towards his M.Sc. at the University of British Columbia on a National Research Council scholarship.

Robert J. Blake, JR.E.I.C. (Toronto '57) has taken a position as plant engineer at the Imperial Tobacco Company's new plant at Guelph, Ont.

Norman Morantz, S.E.I.C. (McGill '59) is studying towards an M.Sc. degree in civil engineering at Lehigh University, Bethlehem, Penn.

Jack W. Hicks, S.E.I.C. (Toronto '59) has taken up the position of construction engineer in Dravo Corporation's contracting division, Pittsburgh, Penn.





NEWS OF THE BRANCHES

BAIE COMEAU

G. W. Scott, M.E.I.C., *Correspondent*

Quebec North Shore Paper Company's Woods Department was host to a number of Baie Comeau members on a 150-mile excursion in the area of the lower Manicouagan River on September 19.

The road-and-water trip included visits to two lumber camps where members saw the latest mechanical equipment for processing and handling pulpwood timber in operation. Of special interest were two entirely original machines for felling, branching and cutting-to-size pulpwood timber without the help of the conventional lumberman and transportation equipment.

Led by Mr. T. B. Fraser, division manager of the Woods Department of the Quebec North Shore Paper Company, the group heard a short talk on the inter-related activities of the company's pulpwood operations and the latest developments by Quebec Hydro on the Manicouagan River.

BELLEVILLE

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

Eighty thousand fires accounting for a $100 million loss occur in Canada each year, Mr. Gordon Shorter, M.E.I.C., Building Research Division of N.R.C., told members at the October 5th meeting.

Mr. Shorter, speaking on Fire Research, showed the film "The Saint Lawrence Burns" and explained that only through objective thinking in field investigations, materials testing, and statistics study can the situation be improved. This, he pointed out, is what his department at N.R.C. is trying to do.

Past-chairman T. E. Flinn introduced the speaker in the absence of the 1959-60 chairman, W. C. Benger.

CAPE BRETON

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

On tour throughout the eight provinces and the Yukon, visiting the Institute's 59 branches, President Hanna addressed the membership here on September 18th. Discusing various aspects of industry across Canada, Mr. Hanna indicated that our economic system was being adjusted to meet modern demands and minimize trends toward depressions. He emphasized that E.I.C. organizations could help by conducting talks and discussions on economic problems, employer-employee relations, and similar subjects.

E.I.C. headquarters are most anxious to help branches with their technical programmes, he stated. Decentralization and maximum service are two constant aims.

Director of Technical Services, J. Hance Legere, expressed the regrets of the General Secretary, Dr. Garnet Page, in not being able to attend the meeting. He stated that headquarters would probably be able to supply one or two speakers for branch meetings. He also reminded members that a staff of qualified librarians is available at the Montreal office to help members obtain any information they may need from technical books and periodicals.

The chairman, W. Dodson, presided over the dinner meeting, held in the Isle Royale Hotel, Sydney, where 43 members were gathered. President Hanna was introduced by the immediate past-chairman, J. Vince Palmer.

CORNER BROOK

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

President Hanna and Dr. Page met the members of the branch at a stag dinner on September 16 in the informal atmosphere of a summer cabin. Dr. Page's work as General Secretary won unanimous acclaim.

Following the dinner Mr. Hanna gave a highly thought-provoking talk on the opportunities and responsibilities of engineers as members of the community. Dr. Page outlined the present activities of the Institute and discussed some of its projects ahead.

HALIFAX

W. J. Phillips, M.E.I.C., *Correspondent*

The Association of Professional Engineers of Nova Scotia held a luncheon and reception at the Lord Nelson Hotel on September 22 in honour of President Hanna. Among the special guests were J. Hance Legere, accompanying Mr. Hanna on the visit; W. J. Phillips, Chairman of the Halifax branch; John H. Boyce, branch secretary-treasurer; and Halifax Branch Councillors G. F. Vail and E. D. Wickwire.

More than fifty members attended the branch meeting that evening—a reception and buffet supper at the Halifax Curling Club. During the day President Hanna had had the chance to renew old friendships among the branch members, including two past-presidents, Drs. J. B. Hayes and Ira P. MacNab.

Speaking to the assembled Halifax members, Mr. Hanna pointed out that the increased enrolment in Canadian universities and migration of foreign engineers to this country had given Canada a good number of qualified engineers and relieved the pressing shortages of four years ago. He reported on current affairs of the Institute and announced that *The Engineering Journal* would expand shortly.

KITCHENER

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

Approximately sixty members from Kitchener, Guelph, Galt and the surrounding area attended the annual stag held at Waterloo Fish & Game Club September 16.

Spareribs and pigtails, baseball, and horseshoes added to the evening's entertainment.

LAKEHEAD

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

Guided by Refinery Engineer Tom Ferris, Safety Engineer Bob Faircloth and Sales Engineer Wayne Cheney, 35 members toured the Husky Oil Refinery on McKellar Island, Fort William on September 16. They were shown various processes used in extracting the many products from crude oil.

In the laboratory, Max Eger, plant chemist, explained the various tests and control methods used to provide consistent products, all of which must meet rigid government specifications.

Dean Stevens, refinery superintendent, explained the operation of the refinery: Forty-five to fifty per cent of the crude is refined into light fuel oils and gasoline. The remainder goes into bunker fuel oil, asphalt, roofing tars, and pipe line enamel. Only about two per cent of the crude is lost in the processing.

The tour and talk were followed by a delicious luncheon given by the Husky Oil Company.

LETHBRIDGE

Ronald J. Knight, JR.E.I.C., *Correspondent*

Members of the Montana Section of the A.S.C.E. were guests of the Lethbridge branch August 29 at the annual tour-and-meeting which is held alternately in Alberta and Montana. Members and guests met for lunch in Waterton and then toured the British American Oil Company's gas and sulphur processing plant at Pincher Creek.

The Lions Club hall in Waterton Lakes was the scene of the dinner meeting. R. L. Francis, JR.E.I.C., welcomed the guests and Mr. L. J. Walker, chairman of the Montana section of A.S.C.E., replied on behalf of our Montana friends. Mr. T. W. Pierce, M.E.I.C., Waterton Lakes National Parks Supt., Alberta, Traced developments in the formation of Waterton Glacier International Peace Park and gave special praise to Rotary International for its ground work and continuing support of this "Hands Across the Border" idea. He even suggested that the park would be a fitting place for a meeting such as ours.

LONDON

L. Scott Murray, M.E.I.C., *Correspondent*

THE LONDON BRANCH of the E.I.C. is conducting a Professional Development Course which consists of seven lectures and a field trip on nuclear energy. This course has been worked out with the cooperation of the University of Western Ontario and McMaster University, as well as Canadian Westinghouse and Canadian General Electric. We are expecting an enrolment of about 40 members.

MONTREAL

J. A. Randle, M.E.I.C., *Correspondent*

THE STUDENT GUIDANCE COMMITTEE of the Montreal Branch met on September 22 and elected Julien Dubuc, JR.E.I.C., chairman of the Junior Section, to its chairmanship.

SASKATOON

W. A. Friebel, M.E.I.C., *Correspondent*

DR. NEIL B. HUTCHEON, assistant director of building research with the National Research Council, Ottawa, spoke to Saskatoon members September 8 giving his impressions of India from a recent trip under the Colombo Plan.

His conclusions, after three months of helping building researchers in India, were that India is "a land of sick people, sick animals and sick apparatus."

Both agriculture and industry in India lag 200 years behind the West and a complex economy does not speed their progress. Compared to Canada's 3.8% arable land India has 48% coupled with a 40-inch rainfall. "India's main problem," stated Dr. Hutcheon, "is to change from a hand production economy to the use of energy and machines."

India must make better use of her cheap labor force, selecting the things they can produce best by scientific methods and discarding the rest. Laboratories better equipped than those in Canada are to be found in parts of India but too often the instruments themselves are not in working order.

• NEWS OF THE BRANCHES

(Continued)

WINNIPEG

Peter M. Abel, JR.E.I.C., *Correspondent*

REPRESENTATIVES OF THE MANITOBA HYDRO-ELECTRIC BOARD conducted sixty E.I.C. members through the Selkirk Generating Station, currently under construction, on September 17.

The capacity of the plant will be 132,000 kw.; two steam generators will provide up to 625,000 lbs. of steam per hr. at a pressure of 875 psi and a temperature of 915° F.; the steam will drive two C. A. Parsons turbine generators, each having a capacity of 66,000 kw. Auxiliary services — the coal handling plant, the water treatment plant, the cooling water system, and the 115 KV switching station were also shown the members.

The Manitoba Hydro-Electric Board kindly served refreshments afterward.

New Officers of the Branches

CHALK RIVER

C. E. Lawrence Hunt, JR.E.I.C., chairman.

C. E. Lawrence Hunt, JR.E.I.C.

LAKEHEAD

P. W. Pinn, M.E.I.C., secretary.

NEWFOUNDLAND

A. E. O'Reilly, M.E.I.C., secretary.

NIPISSING & UPPER OTTAWA

J. M. Rosborough, M.E.I.C., chairman.

R. S. MacLennan, M.E.I.C., vice-chairman.

W. A. Adams, S.E.I.C., secretary-treasurer.

ST. MAURICE VALLEY

W. A. Pangborn, JR.E.I.C., chairman.

W. A. Pangborn, JR.E.I.C.

SARNIA

A. W. Wirth, M.E.I.C., chairman.

VANCOUVER ISLAND

R. W. Lockie, JR.E.I.C., secretary-treasurer.

NEWS OF THE

Associations and Corporation

Registration of Canadian Engineers Reaches 74.1%

A survey conducted in late 1958 by the Department of Labour and recently made public shows that 74.1% of all qualified engineers in Canada are registered. Of 13,534 questionnaires sent out, 10,044 came back with answers. They reveal these figures:

These totals include graduates from accredited engineering courses and non-university graduates who are members of provincial engineering bodies.

Figures include only those who were members of the association in the province in which they were residing. An additional 181 engineers (or 2.4%) reported membership in a provincial association other than the association of the province in which they were residing.

Province	*Total No. of Reporting Engineers(1)*	*No. Reporting Membership in Provincial Association(2)*	*Per Cent*
Newfoundland	42	23	54.8
Prince Edward Is.	10	4	40.0
Nova Scotia	182	111	61.0
New Brunswick	133	75	56.4
Quebec	1,994	1,347	67.6
Ontario	3,589	2,794	77.8
Manitoba	229	166	72.5
Saskatchewan	184	117	63.6
Alberta	596	414	69.5
British Columbia	743	485	65.3
Yukon & Northwest Territories	19	3	15.8
	7,721	5,539	71.7

Quebec Engineers Against Unionism

The proposed revision of the Code of Ethics has recently submitted to the Corporation of Professional Engineers of Quebec as approved by an overwhelming majority. One of the major changes deals with membership of professional engineers in trade unions. It reads:

"The engineer shall not be a member of a Trade Union nor participate as such in any form of Trade Union activities, since he would then uphold a philosophy and certain methods of negotiation, incompatible with true professionalism such as the use of strikes and the like."

The revision will not be effective until approved by the Lieutenant-Governor-in-Council.

Quebec Corporation Campaigning Against Illegal Use of Title "Engineer"

The Corporation of Professional Engineers of Quebec is intensifying its campaign against individuals and firms who are illegally using the title "Engineer". Jean-Paul Dagenais, Jr.E.I.C., of Montreal, has been appointed professional conduct officer by the corporation to investigate all such cases involving infractions of the Professional Engineers' Act.

W. J. Riley, M.E.I.C., president of the corporation, says the eight-man governing council is moving promptly to halt this abuse. He emphasizes that industrialists, contractors and the public at large should realize the dangerous implications arising out of the illegal use of the title.

States Mr. Riley: "Whenever one requires the services of an engineer, one expects to deal with a duly qualified professional whose training at the university and later experience qualify him to undertake and carry out successfully the complicated engineering projects of our day and age."

Opportunities Today Are Better, Says Ontario's Director

Canada's systematic expansion has resulted in better opportunities for engineering graduates than ever before, according to Col. T. M. Medland, executive director of the 18,500-member Association of Professional Engineers of Ontario.

In commenting upon recent reports of falling enrolment in engineering courses at Canadian universities, Col. Medland noted there were 1,299 freshman engineering students registered in Ontario universities and colleges this year. He compared this figure with last year's enrolment of 1,283.

Col. Medland also noted that the number of students taking mathematics and physics in Ontario's twelve universities and colleges which offer engineering is on the increase.

National Society of Professional Engineers (USA)

Engineering employee sentiment toward unions is being tested often these days. A union request for a new election at the Pennsylvania Power and Light Company on charges that the company had unduly influenced the election last December was recently turned down by the National Labor Relations Board. The next major test will probably be among the engineers of Western Electric across the United States. The company, whose election date is coming up, has circulated an 18-page booklet entitled "Why Western Electric Opposes the CWEPE-N Union—A Look at the Record" to its engineers.

Starting salary data from ten leading American engineering colleges (MIT, Columbia, University of Pennsylvania, Lehigh, Case, Purdue, University of Michigan, Northwestern, UCLA, and Georgia Tech) shows a four per cent gain over 1958 and a ten per cent increase over 1957, according to the monthly bulletin published by the Society of Professional Engineers (USA).

News of Other Societies

Testing Laboratories and Chemical Consultants

A crusade for more extensive use of testing and analysis was launched at the annual meeting of the Association of Canadian Testing Laboratories and Chemical Consultants held recently in Toronto.

"In view of recent occurrences where buildings and bridges have collapsed," said E. S. Darby, associate president, "it is evident that testing of construction materials is imperative to prevent such tragedies." He referred to four instances in particular—the recent breakdown of a bridge on Highway 401; the bridge over Burrard Inlet, Vancouver; the steel structure for an industrial building in Toronto; and the collapse of a curling rink in an Ontario city.

The campaign will take the form of a public education project to make manufacturers more aware of the importance of pre-construction testing.

The Association also awarded its first scholarship in the amount of $50 to the Haileybury School of Mines, in memory of a former president of the association, the late J. White.

Canadian Copper and Brass Development

The Canadian Copper and Brass Development Association, a non-trading, non-profit organization, was formed in 1958 under the sponsorship of the copper and brass industry of Canada. Its purpose is "to promote, stimulate and develop the use of copper, its alloys and compounds in all the phases of modern living."

Composed of twenty-five member companies, the association provides technical assistance with manufacturing and processing problems; acts as a liaison with governmental departments on municipal, provincial and federal levels and with other non-trading organizations including the Canadian Standards Association and the National Research Council; supplies technical assistance and information to educational institutions; and endeavors to keep the public informed of existing practices and new developments in the copper-brass field.

European Federation of Chemical Engineering

The European Federation of Chemical Engineering, of which E.I.C. is a member, has recently published a leaflet on its aims, functions and membership.

The federation is defined as "a loose association on a non-profit making basis of technical and scientific societies . . . which are concerned with the fields of chemical technology, chemical engineering and process engineering."

With offices in Frankfurt, London and Paris, the federation aims to "promote European collaboration in the field of chemical engineering, which includes chemical plant engineering, chemical process engineering, and structural materials and unit operations."

It endeavors to keep informed of fundamental data, laboratory techniques, measurement and control techniques, works techniques, and structural materials techniques.

European Congresses about every three years, working parties to deal with individual problems, and constant promotion of the exchange of views among member societies allow the federation to gain and disseminate information vital to the profession of chemical engineering.

American Society of Mechanical Engineers

An estimated 4500 engineers will descend on Atlantic City, New Jersey, late in November for the annual meeting of The American Society of Mechanical Engineers. Under discussion will be the latest developments in hundreds of fields, ranging from rocket ships to textiles. Air pollution, hi-fi radar, plastic pipe and solar air-conditioning will be dealt with in technical papers and discussion. Other sessions will deal with rocket ships for manned space travel, new types of ships that fly above the water, and new and better artificial hands for amputees.

Lieutenant General James M. Gavin, formerly director of U.S. Army Research and Development, will speak on "The Challenge of the 60's".

Recent Meetings

Canadian Construction Association

The second Labour Relations Seminar in Canada for construction executives was held at Banff on October 10 and 11. The seminar, sponsored by the Alberta Builders' Exchange Council, included discussion of 1) the law in union-management relations; 2) management rights and union security; 3) economic determinants in collective bargaining; and 4) the conduct of bargaining.

Plans are in progress for seminars at Quebec City, Dalhousie University, Halifax and Queen's University.

Society for Experimental Stress Analysis

The annual meeting, held on October 21, 22, and 23 in Detroit, Michigan, dealt with Biomechanics. Among the technical papers presented were: The Human Body as a Receiver of Mechanical Energy; Theory of the Transmission of Vibratory Energy through Body Tissue; The Response of the Human Body To Low Frequency Vibrations; Experimental Investigations on Brain Concussion; Structural Response of the Human Body to Acceleration; and The Mechanism of Concussion—An Application of Experimental Mechanics in Neurological Science.

National Conference On Industrial Hydraulics

The 15th Annual National Conference on Industrial Hydraulics, sponsored by the Illinois Institute of Technology, took place on October 22 and 23 in Chicago. Papers were presented on components and accessories, machine tools, pneumatics, pumps, materials forming machinery, mobile equipment, servomechanism and systems, space hydraulics, aircraft systems, automotive subjects, and hydraulic fluids.

Society for Nondestructive Testing, Inc.

The society held its first meeting of the year on October 15 in Montreal. "Qualification and Certification of Nondestructive Testing Personnel" was discussed by a panel of four. Future meetings are being planned to discuss the fields of ultrasonics inspection, eddy current, and isotope radiography.

Coming Meetings

Illinois Institute of Technology: "New Ideas 1960", February 5-6, 1960, at the institute, Chicago, for industrial executives. Subjects: forecasting by product line, improving quality, engineering economics applications, production line balancing and theory, uses of operations research in sales, organization for total quality control, material handling methods, and trends in product design.

Institution of Electrical Engineers, Electronics and Communications Section, London: Third International Conference on Medical Electronics, second half of July, 1960, in London. Object: to disseminate information to medical practitioners and electrical engineers who are not experts in medical electronics and to provide specialist sessions for those engaged in medical electronic work.

International Association for Bridge and Structural Engineering: Sixth Congress, June 27 to July 1, 1960, in Stockholm. Themes to be discussed: basis of structural design, metal structures, steel skeleton, reinforced and prestressed concrete, prefabricated structures, and important progress in bridge and constructional engineering.

LIBRARY NOTES

Prepared by the Library, The Engineering Institute of Canada

RADIOTECHNIQUE ET TELEVISION

Another in the series of "Aide-mémoire" issued by Dunod, these two small volumes contain a wealth of condensed information, including the radio amateurs Code Q, low frequency, capacitance, electronic tube characteristics, construction of radio stations, etc. (H. Aberdam. Paris, Dunod, 1959. 2 vols., 580 fr. ea.)

LA COULEUR DANS LES ACTIVITES HUMAINES, 2IEME ED.

All those concerned with the use of colour will welcome the appearance of this second, revised edition. There are two chapters on the relations between lighting and colour, and a discussion of the physical aspects of colour, and its effect on humans. The second half of the book is concerned with the use of colour in different locations, offices, homes, schools, hospitals, etc. (M. Déribéré. Paris, Dunod, 1959. 351p., 3800 fr.)

ANALYSE DE VARIANCE ET PLANS D'EXPERIENCE

An explanation of the principal results obtained from the analysis of variables, and their applications. It is one volume of a series on probabilities, statistics and operations research. (Daniel Dugué and Maurice Girault. Paris, Dunod, 1959. 68p., 800 fr.)

L'ENTREPRISE ET LA STATISTIQUE TOME 1

One of a series dealing with the economics of plants and other commercial enterprises, this volume is concerned particularly with statistical methods and documentation. After an introductory section the author discusses the history of statistical methods, statistical analysis, and different types of calculating and other machines.

Following chapters consider methods of presentation of results, and their interpretation; the organization of national statistical information especially in France, and the various types of information available—production, prices, employment and wages, banking and commerce, national revenue, etc. A bibliography is included. (R. Dumas. Paris, Dunod, 1959. 402p., 3400 fr.)

NOTIONS SUR LES CIRCUITS D'IMPULSION

Translated from the English, the purpose of this book is to present a basic introduction to impulse circuits. It covers electronic tube circuits, multivibrators, trigger circuits, amplifiers, and applications. (F. J. M. Farley. Paris, Dunod, 1959. 162p., 960 fr.)

INSTRUMENTS ELECTRONIQUES DE MESURE

In this translation from the 1954 English edition, the author surveys the whole field of electronic measurement, the devices used, and the classes of instrument using these devices, with some typical examples. Sections on radiation measurement are found in parts 2 and 3, and there are also sections on cathode-ray instruments, photoelectric measuring instruments and rectifier instruments. Bibliographies are included. (E. H. W. Banner. Paris, Dunod, 1959. 480p., 5400 fr.)

VUES SUR L'AUTOMATISME

A French translation of a report first published by the British Department of Scientific and Industrial Research. The six chapters include a general introduction to the history of automation and the possibilities of automatic production; technical evolution; automatic machining; automatic processing, especially of fluids; automatic data processing; problems of organization; the effect of automation on management and labour.

There is a brief discussion of the future of automation, and a useful bibliography for further reading. (Paris, Dunod, 1959. 140p., 1300 fr.)

EVACUATION ET RECUPERATION DE LA CHALEUR DES REACTEURS NUCLEAIRES

Volume 3 in an introductory series on nuclear engineering, designed to give the reader the scientific basis of atomic reactors.

The topics covered in this volume are: reactor cooling; the use of steam and gas turbines; thermic cycles of some reactors. The two previous volumes were concerned with the physics, control and protection of nuclear reactors. (Richard Alami and Paul Agerson. Paris, Dunod, 1958. 246p., 2900 fr.)

LA FATIGUE DES METAUX, 4IEME ED.

Results of recent research into the fatigue of metals, conducted both in France and abroad, are incorporated into this edition. Some of the topics covered include: the character of fatigue breaks; theory of the mechanism of metal fatigue; fatigue tests; limits of endurance of metals and alloys; the effect of different factors on fatigue, temperature, corrosion, etc.; strength of joints. Long bibliographies are included in each chapter. (R. Cazaud. Paris, Dunod, 1959. 574p., 6900 fr.)

INITIATION AUX PROCESSUS ALEATOIRES

This volume is concerned primarily with the calculation of probabilities, stochastic processes, and Poisson's process. It is another in the series on probabilities, statistics and operational reserch. (Maurice Girault. Paris, Dunod, 1959. 106p., 980 fr.)

PRESENTATION DES STATISTIQUES

With the increased use of statistical analysis, the problem of presentation of statistical information has increased. This volume discusses the methods available, and tries to point out the pitfalls. The first part covers statistical observation, structure and reproduction of charts, and statistical series. Part two considers graphical presentation, describing the various types and their reproduction, and empirical series. Examples are given in all cases. (P. Pepé. Paris, Dunod, 1959. 242p., 3500 fr.)

LES PRINCIPES DE LA THEORIE ELECTROMAGNETIQUE ET DE LA RELATIVITE

A discussion of the basic principles of electromagnetic theory and relativity, in which the topics covered include electrostatics; electromagnetism; Maxwell's theory; Lorentz' theory; principles of relativity before and after Einstein; dynamics; Newton's Law; mathematical analysis. (M.-A. Tonnelat. Paris, Masson, 1959. 394p., 5000 fr.)

FRICTION ET LUBRIFICATION

The first five chapters discuss the various types of friction and their causes, the part played by oxides and surface films, and methods of measuring local temperature caused by friction. The sixth chapter covers friction in nonmetals, while the remainder of the book deals with the behaviour of lubricated surfaces.

The book is based on research carried out at Cambridge University, and is translated from the English. (F. P. Bowden and D. Tabor. Paris, Dunod, 1959. 170p., 1150 fr.)

(Continued on page 101)

• LIBRARY NOTES

(Continued from page 99)

LA COMMANDE ELECTROMAGNETIQUE ET ELECTRONIQUE DES MACHINES-OUTILS, 2IEME ED.

The problems raised by the electro-magnetic and electronic control of machine tools are covered in this manual. The first part discusses general theory, the types of motors used, and speed regulation. Part two is concerned with electro-magnetic control and covers choice of motor and electric apparatus. Electronic control is considered in the last section, which covers electron tubes, thyratrons, servomechanisms, etc. Control plans for both methods are discussed. (A. Fouillé and others. Paris, Dunod, 1959. 332p., 3900 fr.)

RECHERCHE OPERATIONELLE: CAS PRATIQUES ET METHODES

Translated and adapted from the 1956 U.S. edition, this volume is essentially a case book, showing the use of operations research. Discussed are applications in: the U.S. Air Force; British coal mines; delays in toll-collecting; iron ore loading and discharging; stock control; the Monte-Carlo method in a military problem. Most of the articles listed in the fourteen page bibliography appeared in U.S. publications. (J. F. McCloskey and J. M. Coppinger. Paris, Dunod, 1959. 248p., 2600 fr.)

PRATIQUE DE LA MESURE ET DU CONTROL DANS L'INDUSTRIE, TOME 2

The first volume in this series covered pressures, levels, and flows. This volume is concerned with the measurement of temperature, humidity, density and weight. The author reviews the principles of each type of measurement, gives examples of calculations for each important formula, and describes the workings of the different types of instruments available. There is a useful bibliography.

A third volume will cover calorimetric measurement, conductivity, gas analysis, and miscellaneous measurements. (J. Burton. Paris, Dunod, 1959. 392p., 4600 fr.)

BETON-KALENDAR 1959

This German concrete manual, now in its 48th year, contains all its usual features. New material added includes additional German standards related to concrete and concrete construction; arenas; elastic slabs; revised chapters on staircases, and stretcher walls. Much of the material is given in tabular form in this mine of information. (Ed. by Georg Ehlers. Berlin, Ernst, 1959. 2 vols., 20DM.)

SYMPOSIUM ON APPLICATION OF SOIL TESTING IN HIGHWAY DESIGN AND CONSTRUCTION

The papers presented at this 1958 Symposium covered: highway soil engineering; core drilling machines; soil exploration and mapping in Illinois; value of soil test data in road planning; methods of compacting granular soils; Ohio's typical moisture-density curves; compaction characteristics. Of particular interest is a paper on the investigation of banded sediments along St. Lawrence North Shore. (Philadelphia, American Society for Testing Materials, 1959. 127p. $4.00. s.t.p. no.239.)

THE LOGIC OF SCIENTIFIC DISCOVERY

The first English translation of the 1934 German edition, this text has been brought up to date by means of footnotes and 150 pages of appendices. It presents the author's picture of science as an attempt to find a coherent theory of the world, composed of bold conjectures and disciplined by penetrating criticism. The author contends that the growth of science depends on this intellectual daring and rational criticism. Also to be published this year is a complement to this volume, Postscript: After Twenty Years. (K. R. Popper. Toronto, University Press, 1959. 480 p., $7.50.)

VOICE ACROSS THE SEA

Many E.I.C. members will remember the joint meeting held with the I.E.E. and the A.I.E.E. to commemorate the opening of the first Transatlantic telephone cable in 1956.

This is the non-technical story of the laying of submarine cables from the first attempt in 1858, to 1956, and shows convincingly the great progress which has been made in the past century. Many well-known names were associated with the early attempts; Cyrus Field, Lord Kelvin, Samuel Morse, Thomas Edison and Oliver Heaviside, and although the engineers connected with modern cable-laying seem to be largely anonymous, their achievements are equally important. (A. C. Clarke. Toronto, Musson, 1958. 208 p., $3.75.)

MAN-MADE SUN: THE STORY OF ZETA

A relatively non-technical account of recent efforts to harness atomic energy, culminating in the construction of ZETA, zero-energy, thermonuclear assembly, in which temperatures of a million degrees were reached, and maintained for a relatively long time. The book explains the generation of power by electricity, the structure of the atom and its nuclei, thermonuclear reactions, the construction of ZETA, and future sources of power. (J. D. Jukes. Toronto, Nelson, Foster and Scott, 1959. 136p., $3.25.)

METAL INDUSTRY HANDBOOK AND DIRECTORY, 1959

The first three hundred pages of this Handbook include data on the general properties of metals and alloys, British Standards, Ministry of Supply, aircraft and Admiralty specifications. General data and tables are included in Section 2, and information on electroplating and allied processes in Section 3. The Directory Section includes information on British technical and trade associations, a classified directory, and an alphabetical list of firms. (London, Iliffe, Toronto, British Book, 1959. 564p., $4.50.)

HANDBOOK OF THE AIRCRAFT INDUSTRY

The first section of this handbook contains information on the British aviation industry, aeronautical engineering as a career, and the training facilities available in Britain, as well as a who's who of prominent men in the British aircraft industry. Part 2 provides an historical survey, and Part 3 a review of the main aspects of aeronautical engineering. Further sections deal with research and development, guided missiles and civil aviation. Also included are a pictorial guide to modern aircraft, condensed technical data, a glossary of aeronautical terms, and a list of abbreviations. (Ed. by J. L. Nayler and T. F. Saunders. London, Newnes, 1958. 341p., 35/-)

ANALYSIS OF STRAIGHT LINE DATA

Intended primarily for engineers and physical scientists interested in doing their own analysis, rather than relying on a statistician, this volume covers in detail the analysis of experimental data which can be described in terms of linear relationships. Emphasis is placed on the choice of the best method of analysis to use, and the influence of the assumed statistical model on the success of the analysis. Each subject is introduced with data from an actual experiment, and the topics covered include: classical model, x known without error, variance of y constant; samples from bivariate normal populations; several lines, analysis of variance; orthogonal polynomials; the use of transformations; cumulative data, the fading line. There is a useful bibliography. F. S. Acton. New York, Wiley, 1959. 267p., $9.00.)

GLIDING: A HANDBOOK ON SOARING FLIGHT

The author of this volume is Chief Flying Instructor at a British Gliding Centre, and in the first section he explains everything a beginner needs to know before flying solo. The second section contains further instruction, including chapters on safe flying in high winds, aerotows, stalling, spinning and turning. The final section is for the experienced, and is concerned with cross-country flying, cloud flying, soaring, instrument flying, longer flights, and qualifications for international awards. (Derek Piggott. Toronto, Macmillan, 1958. 261p., $5.00.)

THE CANAL BUILDERS

A most interesting account for the general reader of the history of canals and canal builders from the dawn of civilization to the St. Lawrence Seaway. The first canals in Egypt or Mesopotamia were built for irrigation, and later came the canals for navigation and city water supplies. The author describes the Arabian achievements in the Dark Ages, the advances made in Italy during the Renaissance, Brindley, Telford and the English canals, the U.S. canals of the nineteenth century, Suez, Panama and the St. Lawrence. There are several interesting illustrations, and a list of books for further reading. (Robert Payne. Galt, Brett-Macmillan, 1959. 277p., $5.00.)

ROCKET ENCYCLOPEDIA ILLUSTRATED

This encyclopedia, the first in English on the subject, includes information on all aspects of rocketry: rocket power and applications; propellants; engines; assemblies; components; missiles; test and ground equipment; historical events; biographies, etc. Each term is concisely defined, and an explanation in a more readable style appended. There are many illustrations, some of which are here published for the first time, and these are keyed to the text by the use of bold-faced type. Cross references are indicated by italics. A valuable compilation for both the engineer and the layman. (Ed. by J. W. Herrick and Eric Burgess. Los Angeles, Acro, 1959. 607p., $12.50.)

*THE DESIGN OF SHELLS

The fundamental aspects of the design and analysis of shell structures is presented. Although the book deals at length with the theory of the subject, it is practical in its approach to the problems involved, and deals with the design of actual structures, the completion of which are shown in photographs. Aspects treated are the membrane theory, the differential equation of shells, symmetrical problems, the end and North shell, shells with prestressed boundary beams, anisotropic shells, plate approximations, the balanced shear method, and end frames and arch beams. (A. Chronowicz. Toronto, British Book Service, 1959. 202p., $9.50.)

*ENGINEERING STATISTICS

Statistics is presented as a science for making decisions. Following an introduction to the basic fundamentals of probability and distribution theory, a coverage is provided for both the theoretical aspects and practical applications of the normal distribution; the Chi-Square, t, F, Binomial nad Poisson distributions; significance tests, tests about one and two parameters; estimation; fitting of straight lines; analysis of variance; quality control and sampling inspection. Liberal use is made of Operating Characteristics Curves to assist in grasping more difficult statistical concepts, and selected examples are used to solve a wide variety of typical enigneering problems. (A. H. Bowker and G. J. Lieberman. New York, Prentice-Hall, 1959. 585p., $11.00.)

*SYMPOSIUM ON PAPER AND PAPER PRODUCTS

Seven papers intended to acquaint the paper technologist with some of the new developments in paper technology and the methodology which has been evolved. Synthetic fiber papers, internal bonding of paper, and Clupak paper are among the topics discussed. (Philadelphia, American Society for Testing Materials, 1959. 73p., S.t.p. no.241, $2.75.)

*SYMPOSIUM ON STABILITY OF DISTILLATE FUEL OILS

Eight papers dealing with the resistance of fuel oil to breakdown or decomposition. The papers discuss stability problems, past and present, and measures to relieve them. (Philadelphia, American Society for Testing Materials, 1959. 56p., $2.75, S.t.p. no.244.)

*THE EFFECT OF RADIATION ON MATERIALS VOL. III

Papers providing new data on dosimetry techniques; radiation facilities and techniques; and radiation effects on reactor materials and various other materials. (Philadelphia, American Society for Testing Materials, 1959. 169p., $4.25. S.t.p. no.233.)

*REPORT ON PROPERTIES OF CAST IRON AT ELEVATED TEMPERATURES

Report on properties of six commercial low-alloy gray irons, and of one unalloyed ferritic nodular iron, evaluated at 800°F and at 1000°F by means of tensile tests, creep-rupture tests, thermal-shock tests, growth tests and metallographic examinations. Tests showed that the alloys are promising for applications involving thermal shock at temperatures up to 800°F, but not at 1000°F. Development of alloys suitable for use to 1000°F appeared possible. (Philadelphia, American Society for Testing Materials, 1959. 90p., $4.25. S.t.p. no.248.)

*THE STRUCTURE OF METALS

Modern concepts of the electron theory of metals are described. This is followed by a discussion of the experimental techniques which have been developed to test the theory, and to establish such factors as width of the valence band, shape of the "density of states" curves, shape of the Fermi surface, and the numbers and signs of charge carriers in electrical conduction. The dislocation theory of plastic deformation is then presented, and the experimental techniques associated with it described. The papers in this book constitute lectures given at the Institution Metallurgists refresher course in 1959. (Toronto, British Book Service, 1959. 118p., $6.00.)

*OPERATIONS RESEARCH

This text begins with a brief survey of the elements of probability theory, including the concepts of probability of an event, randon variable, probability distribution, and conditional probability distribution. Sampling is then discussed, and an introduction is given to the Monte Carlo method of simulated sampling. Succeeding chapters present various problem areas in operations research, specifically, inventory, replacement, waiting lines, competitive strategies, allocation, sequencing, and dynamic programming. (M. Sasieni and others. New York, Wiley, 1959. 316p., $10.25.)

*SURVEYING, 4TH ED.

In addition to the basic principles of surveying, sufficient information is provided to develop a sound working knowledge of special surveying topics such

(Continued on page 107)

• LIBRARY NOTES

(Continued from page 104)

as photogrammetry and the use of accurate design topographic maps for determining earthwork quantities. In this edition not only have changes been made to bring the book up-to-date, but major changes in the presentation have been made as well. This is particularly true in the case of modern surveying equipment and practices, which are introduced early in the book. (H. Bouchard and F. H. Moffitt. Scranton, International Textbook Co., 1959. 664p., $10.50.)

°SAMPLING INSPECTION TABLES, SINGLE AND DOUBLE SAMPLING, 2ND. ED.

The previous edition presented a working set of sampling inspection tables for control of quality and economy of inspection within a manufacturing plant. In addition to these tables, the present edition contains a collection of "Probability-of-acceptance" curves called Operating Characteristic curves. These curves may be used to determine how particular sampling plans chosen from the tables will operate for all possible levels of presented quality. The use of the sampling tables is discussed, and a new chapter is included which discusses the practical significance of the Operating Characteristic curves. (H. F. Dodge and H. G. Romig. New York, Wiley, 1959. 224p., $8.00.)

°INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, PUBLICATIONS 1958

Papers dealing with such topics as analyzing deformations of plane trusses, general instability of low framed buildings, bending of a sectorial plate, stability of pony-truss bridges, stability of rib-reinforced cylindrical shells under lateral pressure, cyclic loading of portal frames, analysis of thin elastic shallow segmented shells, and a model continuous beam bridge with steel deck. Papers are written in English, French and German with summaries of each paper in all three languages. (Switzerland, Verlag Leeman, 1958. 296p., 40 Sw fr.)

°SERVOMECHANISMS AND REGULATING SYSTEM DESIGN. VOL. 1, 2ND. ED.

The nature of the feedback control system problem is described and an analytical approach to servomechanism and regulator design is presented. Emphasis is placed on the complex plane, the attenuation-frequency, and root-locus methods of control system analysis of both simple and more complex systems. In conjunction with the multiple-loop systems, techniques are described for complicated control problems with simplified analysis methods. The use of these methods permits the designer to arrive at a workable design fairly readily. The present edition reflects recent advances within the field. (H. Chestnut and R. W. Mayer. New York, Wiley, 1959. 680p., $11.75.)

°HIGH TEMPERATURE MATERIALS

A summary of the state of knowledge as well as of recent developments in the field of materials for use at temperatures above 1500°F. The characteristics of nickel- and cobalt-base alloys and cermets are summarized and the factors that control their performance are indicated. This is followed by a discussion of refractory metals, and of dispertion hardening as a means of obtaining high strength. The concluding portion of the book deals with gas-metal interactions and considers vacuum melting and its effects on properties, the effect of testing environment on properties, and oxidation resistance. The papers in this book constitute the proceedings of a conference held in Cleveland, Ohio in 1957. (Ed. by R. F. Hehemann and G. M. Ault. New York, Wiley, 1959. 544p., $17.50.)

°GROUND WATER HYDROLOGY

An account of ground water hydrology that presents the fundamentals of the subject as well as recent methods being used in the field. The basic quantitative aspects relating to use, occurrence, movement, water wells, and ground water levels are followed by discussions of ground water quality, conservation of ground water, methods of investigating ground water by surface and subsurface procedures, artificial recharge, and sea water intrusion. A review is also given of the various types of laboratory model and numerical analysis studies. (D. K. Todd. New York, Wiley, 1959. 336p., $10.75.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Aircraft

Pressure distribution and force measurements on a VTOL tilting wing-propeller model; part 1: description and tabulated results, by J. A. Dunsby and others.

Some data on elevator damping and stiffness derivatives on a delta wing aircraft model at supersonic speeds by K. J. Ruckeman. Ottawa, N.R.C., National Aeronautical Establishment, 1959. (LR-252, LR-250).

Beams and girders

Normal mode analysis of beams of non-uniform cross-section with tabulated results for some linearly tapered clamped-pinned beams, by R. S. Julius and S. Ranta. Ottawa, N.R.C., National Aeronautical Establishment, 1957. (LR-210).

Bibliographies

Bibliography of periodical literature on Canadian geography, 1930-1955; part 3. Quebec and Ontario. Ottawa, Geographical Branch, 1959. (Bibliographical Series No. 22) 50c.

City planning: a basic bibliography with special reference to civil en-

gineering and land surveying, by G. C. Bestor and H. R. Jones. Sacramento, Calif. Council of Civil Engineers and Land Surveyors, 1957.

Pumped storage for hydro-electric power; a selected list of references in English. Knoxville, Tennessee Valley Authority, Technical Library, 1959.

Canada. Mining

Coal mines in Canada. Ottawa, Dept. of Mines and Technical Surveys, Mineral Resources Div., 1959. (Operators list 4). 25c.

Chloride Salt

Ice melting properties of chloride salt mixtures. Wash., N.R.C., Highway Research Bd., 1959. (Bulletin 220). 50c.

Concrete reinforcement

Reinforced concrete design handbook of the American Concrete Institute, 2d ed. Detroit, American Concrete Institute, 1955.

Helium

The story of the early days of the extraction of helium gas from natural gas in Canada, 1915-1920, by J. Satterly. Ottawa, Mines Branch, 1959. (Information Circular no. 105.) 25c.

Industrial resources

Man and raw materials, by E. W. Pehrson. Phila., ASTM, 1958. (Edgar Marburg Lecture, 1958.)

Muskeg

Muskeg access: the slipe-haul method, by J. Cuthbertson and N. W. Radforth.

Proceedings of the fifth muskeg research conference, 4 March 1959. Ottawa, N.R.C., Associate Committee on Soil and Snow Mechanics, 1959. (Technical memoranda nos. 58 and 61.)

Permafrost

Proceedings of the permafrost research conference at the Bldg. Res. Centre, Ottawa, March 27, 1958. Ottawa, N.R.C., Associate Committee on Soil and Snow Mechanics, 1959. (Technical memorandum no. 60.)

Science. History.

From Euclid to Eddington; a study of conceptions of the external world, by Sir E. Whittaker. New York, Dover, 1958. $1.35.

On mathematics and mathematicians, by R. E. Moritz. New York, Dover, 1958. $1.95.

Philosophy and the physicists, by L. S. Stebbing. New York, Dover, 1958. $1.65.

The philosophy of space and time, by H. Reichenbach. New York, Dover, 1957. $2.00.

Slabs

The freezing and melting times of slabs and cylinders, by D. C. Baxter. Ottawa, N.R.C., 1959. (Mechanical engineering report MK-1).

Soil mechanics

Proceedings of the twelfth Canadian soil mechanics conference, Dec. 8 and 9, 1958. Ottawa, N.R.C., Associate Committee on Soil and Snow Mechanics, 1959. (Technical memorandum no. 59.)

Technical writing

Writing and publishing technical book; how to prepare manuscripts of business, industrial, engineering and professional books—and how to arrange for their publication. New York, Dodge, 1959. Free.

Turbines

Untersuchungen über den Ventilationsverlust von Turbinenrädern, by P. Suter and W. Traupel. Zurich, Verlag Leeman, 1959. Sw. Fr. 6.

Wave mechanics

A drift monitoring system and a rapid calibrating technique for the capacitive wave profile recorder, by R. J. Harron. Ottawa, N.R.C., 1959. (Mechanical engineering report MI-818A.)

New Journal

The Institution of Mechanical Engineers announces publication of a new quarterly, the Journal of Mechanical Engineering Science. Its object is to permit effective reporting of contributions of a specialized and scientific nature, prepared by authors engaged in fundamental research in the field of mechanical engineering. The subscription will be £3 a year. A copy of the first issue is on file in the E.I.C. Library, for members to examine.

Dexion (Canada) Limited announces the opening of a new Montreal office and warehouse at 5085 Cote de Liesse Road.

International Rectifier of Canada, Ltd. has opened an Ottawa office at 1581 Bank Street.

Conference Schedule

Institute of Radio Engineers, Aeronautical and Navigational Engineers, East Coast Conference, Baltimore, Md., October 24-26.
Institute of Radio Engineers, Electronic Devices Meeting, Washington, D.C., October 27-29.
American Institute of Chemical Engineers, Sheraton Palace, San Francisco, December 6-9.

The Canadian Chromalox Company Limited has introduced their new electric cabinet convector heaters. Constructed of heavy-gauge metal, these units are designed to permit easy air access through the bottom louvers.

Graver Water Conditioning Company (**A Division of Products Tank Line of Canada, Ltd.**) has developed a spur-gear drive for heavy-duty applications of the Rota-Rake clarifier and thickener. The Rota-Rake is a horizontal flow water and liquid-treatment unit for gravity sedimentation and sludge thickening.

Conference Schedule

American Oil Chemists' Society, Fall Meeting, New York, October 17-19.

The 1959 Gilbreth Medal Award of the Society for Advancement of Management was presented to Gerald B. Bailey of Woods, Gordon & Co., Toronto, at the society's 14th Annual Management Engineering Conference in New York.

Sarnia Scaffolds Limited, with head offices at Berryman Avenue, St. Catharines, Ontario, and branch offices across Canada, will continue the scaffold business established by Sarnia Bridge Company Limited and Sarnia Scaffolds (Western) Limited, distributing the same products and specializing in the sale and rental of equipment to the construction industry.

Canadian National Railways reports the foundations for steel work have been completed and the Dominion Bridge Company is ready to erect steel on their new 17-storey headquarters office building at the corner of Mansfield and Lagauchetiere Streets in Montreal.

The Canadian Choromalox Company Limited announce their new catalogue **CC-59** showing the latest developments in the home, commercial and industrial electric space heating applications. Copies available free, on request.

Design Engineering's directory of suppliers for 1960 will soon be available to assist the design engineer in his choice of materials and where to buy them.

Bepco Canada Limited's Bepco Journal treats of electro-mechanical brakes in the September issue. For the Bepco Journal or literature on Bepco products write to the head office at 4018 St. Catherine St. West, Montreal.

Standard Wire and Cable Limited, Toronto, have just issued a one-page price list which enables the purchasing man to shop for a whole range of products at a glance.

Armco Drainage and Metals Products of Canada Ltd. report the successful use of a large flat-bottom corrugated metal underpass structure to carry small farm lanes and service roads under limited access highways.

Industrial Research Magazine (summer issue) describes applications of new devices being developed by Underwater Manipulators for keeping waterways ice-free in winter, aerating ponds and lakes, controlling waves, communicating through water, and mining the ocean-bottom.

Canadian Applied Research Limited announce the introduction of the ANADAC (Automatic Navigation Display and Computer) series of dead reckoning navigation instruments. These are designed and manufactured by CARL who also produce ice detectors designed for airframe and engine intake installations.

The Master Builders Company Ltd., Toronto, have available a free Bulletin MBR-P8 containing twelve case histories of tunnel concreting.

Warnock Hersey Company Limited have published the first issue of their house magazine W. H. News, which deals with hidden problems of seaway construction.

Creosote Information Bulletin, Vol. 2 No. 5, published by the coal tar products division of Dominion Tar and Chemical Company, Limited gives a through description of leaching (insect burrowing) in untreated wood used for marine piling.

Canadian Dexion News, Vol. 3 No 3, describes with pictures many uses for Dexion slotted angles and grid. They can be quickly assembled and are rust-proof and lightweight. For catalogue and price list write Dexion (Canada) Limited, 114 Clayson Road, Toronto 15.

Gypsum, Lime & Alabastine Limited's summer bulletin Vol. 27, No. 2 entitled

"The Clearing House" describes and illustrates ornamental plaster work in churches and other buildings.

American Air Filter Company of Canada Ltd. has released a new product bulletin describing the characteristics and operation of the Amerclone dry, centrifugal dust collector. This Bulletin 291A is available upon request from the company at 400 Stinson Blvd., Montreal 9.

James Howden & Company of Canada Ltd., 1510 Birchmount Road, Scarborough, Ont., has a 16-page brochure available illustrating how fuel costs can be reduced with the Package Ljungstrom Air preheater.

• MONTH TO MONTH

(Continued from page 91)

Milne, James R. B., Kenogami, Que.
Palmer, Byron C., Toronto, Ont.
Pouliot, Adrien, Que., Quebec.
Sawyer, John E. B., Vancouver, B.C.
Smith, Joseph A., Montreal, Que.
Ulrich, Victor G., Vancouver, B.C.

Juniors

Ayukawa, R. N., Regina, Sask.
Blair, Robert H., Oakville, Ont.
Boileau, G. G., Hull, Que.
Brazeau, Gerard, Montreal, Que.
Brillon, Michel, Westmount, Que.
Brooy, Walter J., Toronto, Ont.
Carter, Donald C., Valois, Que.
Clarabut, John F., Petawawa, Ont.
Curry, Robert G., Spragge, Ont.
Eyolfson, O. L., Montreal, Que.
Fredryk, Ernest D., Hamilton, Ont.
Gauthier, G. M., Montreal, Que.
Gould, Angus J., Morrisburg, Ont.
Hay, Ranald L., R.R. 2, Mono, Ont.
Higgins, Charles W., Jersey City, N.J. U.S.A.

Juniors

Hyslop, Harvey R., Ottawa, Ont.
Johnston, George F., Asbestos, Que.
Kirkland, James G., London, Ont.
LeBlanc, Paul E., Ottawa, Ont.
Lind, Niels C., Urbana, Ill., U.S.A.
McCully, Gerald R., Ottawa, Ont.
McGowan, James F., Sillery, Que.
Mollo-Christensen, S., Montreal, Que.
Morrison, Robert N., Montreal, Que.
Mulder, T. E., Vancouver, B.C.
Polischuk, R. H., Montreal, Que.
Rowledge, Joseph J. S., Burnaby, B.C.
Smythe, William D., Peterborough, Ont.
Stretton, J. A. J., Kitimat, B.C.
Strynadka, John, Vancouver, B.C.
Talbot, Guy, Quebec, Que.
Townson, Arthur, Inkster, Mich., U.S.A.
Zakaib, Lorne J., Montreal, Que.

Students

Baron, Claude R., Ottawa, Ont.
Beare, John W., Winnipeg, Man.
Besant, Robert W., Norwood, Man.
Brunet, Robert, Montreal, Que.
Baj, Casimir, Montreal, Que.
Chenier, George E., Plantagenet, Ont.
Chiasson, R. M., Montreal, Que.
Churchill, R. J., Dartmouth, N.S.
Cloutier, B. R. F., Ottawa, Ont.
Comtois, Gerard J. P., Quebec, Que.
Cormier, Rene, Montreal, Que.
Diab, Edgar W., Halifax, N.S.
Drummond, A. M., Vancouver, B.C.
Fletcher, Thomas B., Saskatoon, Sask.
Giannetti, Alfred, Montreal, Que.
Gross, Harry, Toronto, Ont.
Hallas, H. G. B., Kingston, Ont.
Jenkins, Garth H.
Jew, N. S., Prince Rupert, B.C.
Lawless, Arnold A., Toronto, Ont.
Lunder, Jakob, Vancouver, B.C.
MacLean, Donald N., Calgary, Alta.
Major, J. L., Montreal, Que.
McAthey, Gordon R., Vancouver, B.C.
Parkinson, John P., Edmonton, Alta.
Prives, Eric, U. M., Montreal, Que.
Russell, William R., Toronto, Ont.
Schmidt, Jean G., Montreal, Que.
Snyder, Robert B., Saskatoon, Sask.
Straveley, Douglas E., Kenora, Ont.
Widholm, O. R., Scandia, Alta.

Gigantic Pipes o' Pan? No, but . . .

DAVIESHIP can build any size or shape of engineering structure you may require!

It would take a gargantuan Pan to lift that 25-ton steel Half Arch Pipe! It is 6′ in diameter and 130′ long from base to tip of cone. Yet this fantastic pipe is only one of 48 which DAVIESHIP is building for the Cargill Grain Company's new Baie Comeau grain terminal — and only one portion of the order now being filled for them at DAVIESHIP. Other portions include a grain warehouse, headhouse, storage bins, hoppers, casings and shipping galleries. As you can see, no steel fabrication is too large or too intricate for the DAVIESHIP Engineering Division to handle! Give us a call if we can serve you in any way.

D DAVIESHIP

THE BIG 'D' STANDS FOR 'BIG DAVIE'

DAVIE SHIPBUILDING LIMITED, LAUZON, QUE.

SHIP BUILDING · SHIP REPAIRING · PRESSURE VESSELS · PENSTOCKS

GATES · STEEL STRUCTURES · INDUSTRIAL MACHINERY & EQUIPMENT

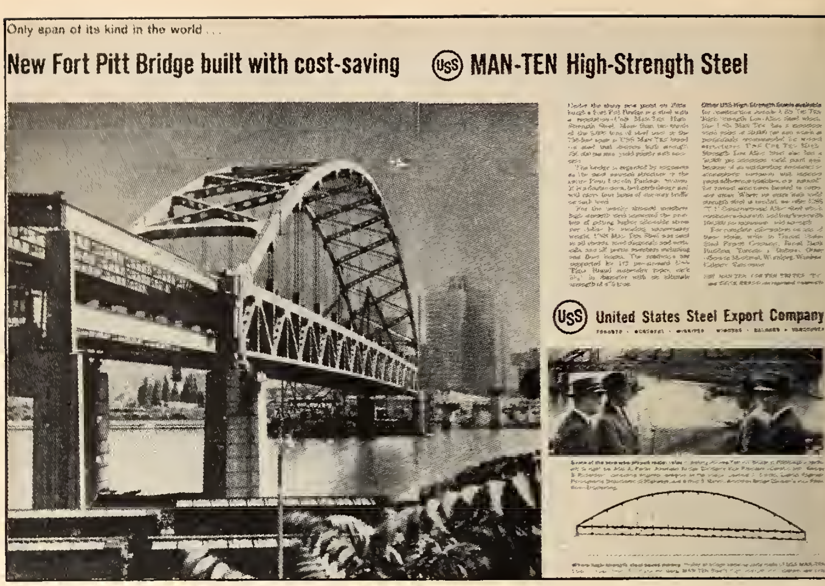
E. I. C. CERTIFICATE OF ADVERTISING MERIT

In the August 1959 issue, the advertisement of the United States Steel Export Company was judged the "best" by the fifty readers who were asked to scrutinize the advertisements. The advertisement occupies pages 10 and 11.

The advertisement, printed in blue and black, features the "ONLY SPAN OF ITS KIND IN THE WORLD . . . NEW FORT PITT BRIDGE BUILT WITH COST-SAVING USS MAN-TEN HIGH-STRENGTH STEEL."

A new jury of readers serves each month. The members are asked to select what they consider to be the "best" advertisement, in the issue under consideration, from the viewpoints of ACCURACY — INFORMATION and ATTRACTION.

The E.I.C. Certificate of Advertising Merit won by this advertiser will be presented to Mr. W. Jones, Manager of the Advertising & Market Development and a duplicate will be presented to Batten Barton, Durstine & Osborn Inc., the advertising agency which prepared and placed the advertisement.



UNITED STATES STEEL EXPORT COMPANY WINNING ADVERTISEMENT

Reproduced above is the United States Steel Export Company's advertisement which was judged the "best" in the August issue by a fifty reader jury. Judging was based on ACCURACY–INFORMATION and ATTRACTION. The copy of the advertisement is concise and outlines the materials used for the construction of the bridge. It concludes by giving the addresses to be used to obtain complete information on the steels used in the bridge.

1954 Graduates: Field of Scholastic Specialization in 1954 by Employment Status in 1957
(Percentage Distribution)

Employment Status	*Field of Specialization in 1954*											
	Aeronautical Engineering	*Chemical Engineering*	*Civil Engineering*	*Electrical Engineering*	*Engineering and Business*	*Engineering Physics*	*Forest Engineering and Forestry*	*Geological Engineering*	*Metallurgical Engineering*	*Mechanical Engineering*	*Mining Engineering*	*Petroleum Engineering*
Employed Full Time	—	93.3	97.1	97.0	96.4	82.1	88.6	81.5	95.5	100.0	87.1	100.0
Employed Part Time	—	—	.8	1.2	—	—	1.3	3.7	—	—	4.3	—
Unemployed	—	—	—	.6	—	—	—	—	—	—	—	—
Student	100.0	6.7	2.1	—	3.6	17.9	10.1	14.8	4.5	—	4.3	—
Retired and Other	—	—	—	1.2	—	—	—	—	—	—	4.3	—
Percentage	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
No. of Persons Representing Percentages	1	119	236	169	28	28	79	27	22	184	23	10

Annual Rates of Change in Employment of Engineers, by Employment Sector, 1957 and 1958-1960

Employment Sector	*Actual Employment* — *Percentage Change in Employment During 1957*	*Forecast Employment* — *Average Percentage Forecast Change in Employment 1958-60*
Engineers — all sectors	+10.1%	+ 5.5%
Total industry	+10.5	+ 5.1
Mining and quarrying	+ 9.3	+ 3.2
Manufacturing	+11.8	+ 5.5
Construction	+10.9	+ 9.0
Transportation and public utilities	+11.3	+ 4.1
Trade and finance	*	*
Business service	− 4.8	+ 3.6
Colleges and universities	+11.1	+10.3
Government agencies	+ 7.1	+ 7.2

Annual Rates of Change in Employment of Engineers, by Professional Field, 1957 and 1958-1960

Professional Field	*Actual Employment* — *Percentage Change During 1957*	*Forecast Employment* — *Average of Percentage Changes 1958-60*
All Engineers	+10.1%	+5.5%
Mechanical	*+12.0*	*+6.3*
Chemical	*+12.2*	*+6.0*
Civil	*+ 8.3*	*+5.8*
Metallurgical	*+13.6*	*+5.5*
Electrical	*+ 8.8*	*+4.8*
Aeronautical	*+ 9.1*	*+4.2*
Geological	*+12.6*	*+3.8*
Mining	*+ 6.1*	*+2.7*

Difficulties in Recruiting Engineers by Professional Field, 1956-1960

Engineering Field	*Total Number of Employers of this Profession*	*Employers Reporting Recruiting Difficulties in 1956-1957*		*Employers Expecting Recruiting Difficulties in 1958-1960*	
		Number	*Per Cent*	*Number*	*Per Cent*
Aeronautical	38	9	23	6	16
Chemical	362	59	17	25	7
Civil	474	57	12	35	7
Electrical	448	82	18	47	11
Geological	92	12	13	4	4
Mechanical	722	177	16	54	8
Metallurgical	206	36	18	25	12
Mining	205	24	12	11	5

• CANADIAN DEVELOPMENTS

(Continued from page 86)

the 1954 graduates, as shown in the report, undoubtedly reflects this favourable demand situation, inasmuch as some sectors of the economy were able to attract young graduates and influence their decision either to the labour force or to undertake postgraduate study.

Tables extracted from a preliminary release of tabulations by the Economics and Research Branch, Department of Labour: "ENGINEERING AND SCIENTIFIC MANPOWER RESOURCES IN CANADA: Their Earnings, Employment and Education, 1958", Ottawa, August, 1959.

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

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December 1959

vol. 42 no. 12

Cables: Enginst-Montreal
PRINTED IN TORONTO

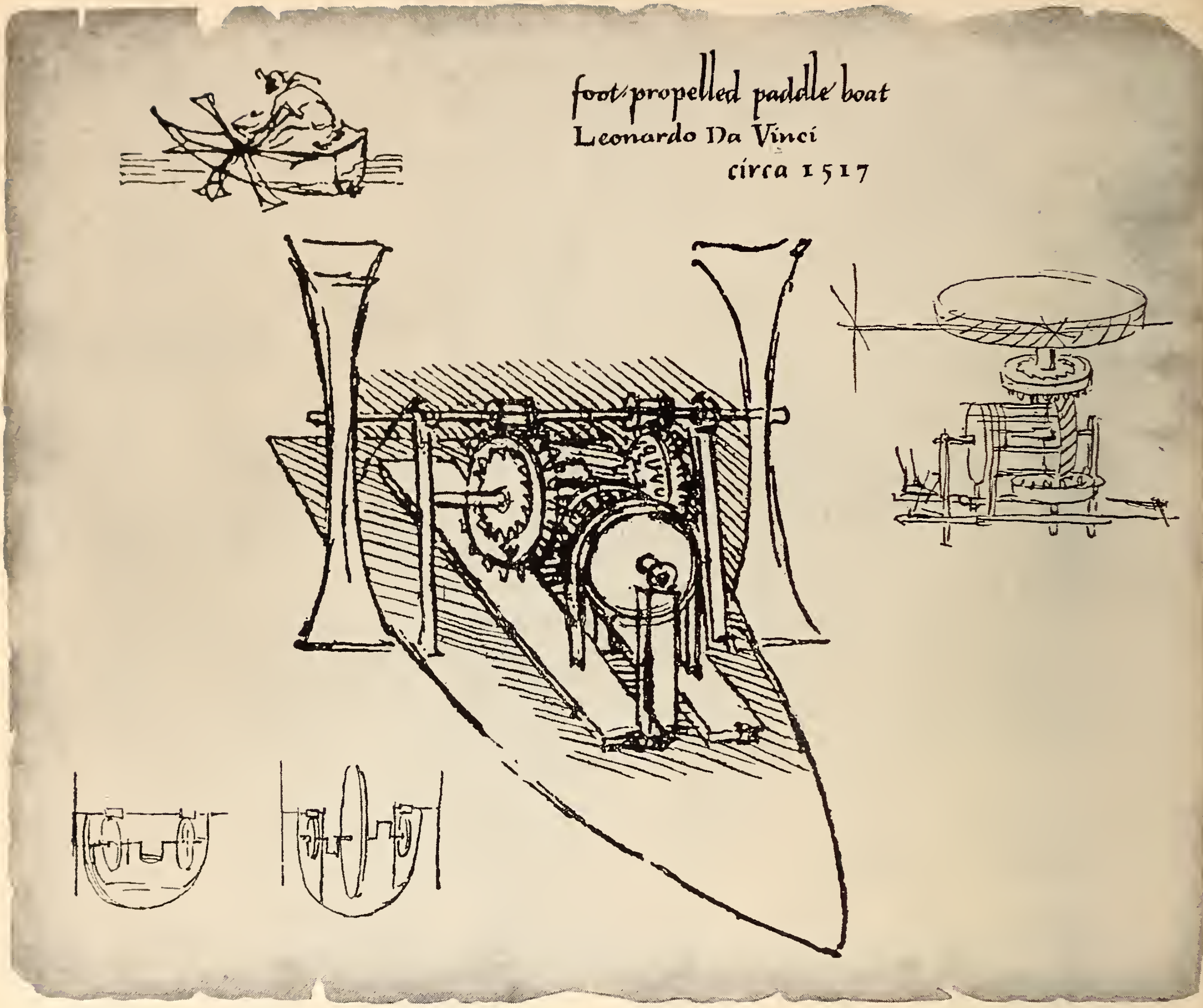
Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members and affiliates, 50 cents a copy, $4.00 a year.—Authorized as second class mail, Post Office Department, Ottawa.

MEMBERSHIP

ABC CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index
The Canadian Business and Technical Index.

(19,800 copies of this issue printed)



LEONARDO DA VINCI *possessed what was possibly the most imaginative and versatile mind of all time. He was, among other things, an artist, an engineer, and an inventor. Reproduced here are original sketches by Da Vinci for a foot-propelled paddle boat, showing details of gear mechanism, paddles, cam, and fly wheel.*

IMAGINATION

In their offices and drafting rooms and in their huge, all-enclosed yards, Canadian Vickers put imagination and creative skills to work. Here, ships are built on a year-round basis . . . passenger ships, destroyer escort vessels, tankers, tugs, ferries, dredges, scows . . . all built by Canadian Vickers to play an important role in our economy.

In their shops, Canadian Vickers also design and manufacture machines and equipment for every imaginable industrial need . . . thereby fulfilling their pledge: "If Industry Needs It . . . Canadian Vickers Builds It . . . Better."

Ships • **Industrial Boilers**

Special Machinery Equipment • **Chemical Process Equipment**

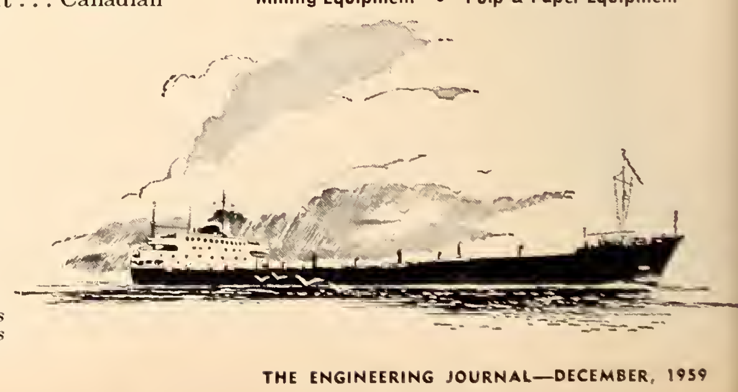
Marine Equipment • **Hydraulic Machinery**

Mining Equipment • **Pulp & Paper Equipment**

CANADIAN VICKERS LIMITED

MONTREAL • TORONTO

MEMBER OF THE VICKERS GROUP



Ore carrier built by Canadian Vickers for service on the Great Lakes

A MESSAGE FROM THE PRESIDENT

For many months the Council has been considering ways and means of expanding the technical content of *The Engineering Journal.* At the same time, consideration was given to the wider dissemination of the information the publication contains.

After a thorough study and surveys extending from February through August, the Finance Committee and the Publications Committee recommended, and the Council decided that the distribution of *The Engineering Journal* is to be enlarged to reach over 32,000 Canadian engineers. This will enable the publication to render an improved and enlarged technical service to the maximum number of engineers. Members and non-member engineers alike will receive the Journal at no charge, as a result of this expanded E.I.C. service to Canadian engineers. Commencing January, 1960, E.I.C. members will not be required to pay the annual subscription for the "Journal".

During the Fall of 1959, I visited about half of the branches, and told them about the Institute's new policy for the circulation of *The Engineering Journal* beginning with the January 1960 issue. However, since some branches will not have received this information directly from me prior to the end of the year, I am having this message printed in the December issue so that every member may know of this new policy, and the reasons for it.

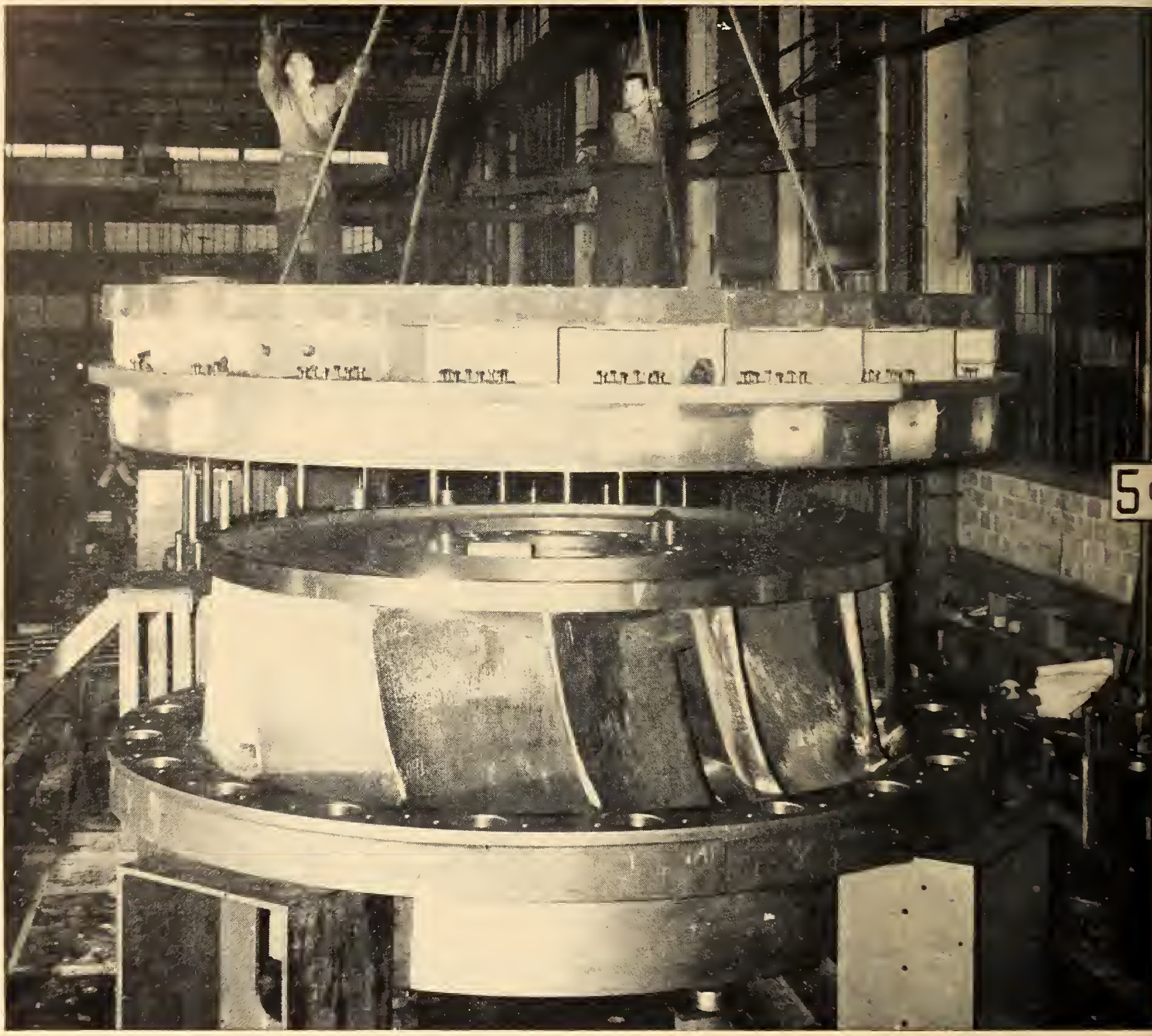
Naturally, to be successful in this enlarged area of service to the profession, *The Engineering Journal* must continue to receive the support, helpful suggestions and, most important of all, technical papers of high quality from the membership.

Most E.I.C. members will probably read this message during the Christmas season. May I, therefore, conclude by extending to you and your loved ones my most sincere best wishes for a wonderful Christmas and a pleasant and successful New Year.

Yours truly,

J. J. HANNA, M.E.I.C.
President
THE ENGINEERING INSTITUTE
OF CANADA

SHIP TO HYDRO QUEBEC AT BERSIMIS NO.2



Bersimis No. 2 will add another 900,000 h.p. to Quebec Hydro's capacity for meeting the ever increasing demand for power in the Province. The site, 22 miles downstream from Labrieville on the Bersimis River, provides a gross head of 386 feet. The tunnel for the water supply measures 38 feet in diameter and 2,692 feet in length; the water will flow at a velocity of 21 feet per second when all units are operating at rated load.

Five Dominion Francis Turbines of 180,000 h.p. each, running at 163.6 rpm, drive vertical generators of 120,000 KVA. They will produce 2,500 million KWH annually—more power than the total capacity available in Chile.

The photograph above was taken during test assembly at Dominion to check runner clearances between the head cover and lower ring.

Write for Bulletin 201—"Hydraulic Turbines".

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Dr. Campbell graduated in 1951 from the University of Manitoba with a B.Sc. in civil engineering, and received his M.Sc. from Purdue University in 1952. After two years on the staff of the Federal Department of Public Works, Ottawa, he returned to Purdue University where he earned a Ph.D. degree in 1956. For the next year Dr. Campbell was engineer-observer for the Canadian Good Roads Association at the AASHO Road Test at Ottawa, Illinois. In the fall of 1957 he was appointed to his present position.

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In 1959, he was appointed to a C.S.A. Committee on High Voltage Power Cable.

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Mr. Gent is a graduate of the Institute of Civil Engineers, London, England, 1934. He has held various positions with navigation and land drainage authorities, including the City of Westminster and the River Nene Catchment Board. In 1947 he joined James Williamson and Partners, Glasgow and in 1948 came to Canada to work for H. G. Acres and Company Limited, where he is now in charge of hydraulic model studies in the laboratory and experimental hydraulic and stress measurements in the field.

J. N. Mustard, assistant engineer-in-charge, concrete control department, The Hydro Electric Power Commission of Ontario (*The Use of Fly Ash in Concrete by Ontario Hydro*).

Mr. Mustard graduated from the University of Toronto with a B.A.Sc. in civil engineering in 1941. He was overseas with the Royal Canadian Engineers from 1941 to 1946 and has worked since with the Ontario Hydro.

At time of going to press no information was available on Mr. C. MacInnis, Jr.E.I.C., co-author of the above paper.

F. S. Howes, professor of electrical engineering and director of university extension at McGill University (*Something Can Be Done About Noise*).

Dr. Howes received his B.Sc. with honours in electrical engineering from McGill in 1924 and his M.Sc. in 1926. The Ph.D. degree was granted by the University of London in 1929. He returned to McGill University as a lecturer in electrical engineering in 1929 and was appointed director of University Extension in 1949.

Dr. Howes is a fellow of the Institute of Radio Engineers and a member of the Corporation of Professional Engineers of Quebec.

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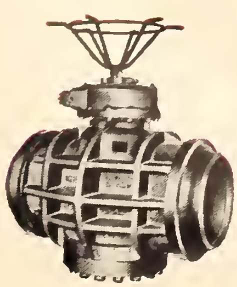
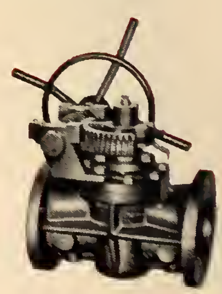


HIGHWAY RESEARCH ACTIVITIES IN CANADA

Gordon D. Campbell, M.E.I.C. *Director of Technical Services*
Canadian Good Roads Association, Ottawa, Ont.

Presented to the Seventy-Second Annual General Meeting of The Engineering Institute of Canada, Quebec City, May 23, 1958
Revised and resubmitted for publication November 1959

In recent years the Canadian Good Roads Association has developed as the clearing house for Canada of technical information related to roads and streets. CGRA has organized to stimulate research, publish and distribute information on technical developments and to bring together specialists from all parts of Canada to discuss and resolve common problems in their special branches of highway technology.

As the co-ordinating agency for road research in Canada, CGRA has compiled and published a complete list of all road research projects currently under way or recently completed in Canada. This list contains a description of each project, where it is being done, by whom it is being done, the starting and completion dates, and where the results are available. The survey is intended to co-ordinate research work, to aid practising engineers in incorporating new findings into current practice, to expose areas requiring urgent attention and to stimulate new research work.

The results of this first survey indicate that approximately $1,000,000 was spent in 1958 for road and street research and development in Canada. Thus, for every $1,000 spent on roads and streets in Canada in that year approximately one dollar was spent on basic or applied research. The initial report lists 159 individual road research projects, each dealing with a specific technical problem, under way in Canada today. This data, though encouraging, indicates that Canada lags well behind the United States highway industry and other private industries in its rate of investment in road research. Research must be stepped up to solve Canada's own unique problems and to keep pace with road development in this country.

Introduction

TWENTIETH CENTURY man is very conscious of research. The reason, of course, is that he knows its value. Each year the new products of research and development increase the comfort of modern living, raise the standard of living and increase the hours of leisure. Today we wear nylon shirts, shave with electric razors, buy our food in plastic containers, fly across the country in a few hours and drive to work or pleasure in comfortable, even luxurious automobiles. Such developments did not just happen. Industries methodically set aside as much as two per cent or more of their total income for research and development.[2, 7] These large expenditures are a proven investment which pay off in improved products and lower costs.

Road research and development have lagged well behind the need. This is evident from the deplorable traffic accident statistics, the congested arterial streets and the high percentage of failed pavements on both the rural roads and city streets of Canada. All of these deficiencies could be substantially reduced or overcome completely through adequate planning, better design techniques, improved materials and the better use of existing materials. We should learn the lesson of industry and devote more time, effort and money to road research. This too will pay off in lower road construction costs, lower vehicle operating costs and improved road service.

Road research also lags behind development in other fields of engineering and civil engineering. There is a reason for this. It was explained in 1927 by the world-famous civil engineer Dr. Karl Terzaghi. In speaking to the Boston Society of Civil Engineers about one of the earliest road research projects he said:

"The attempt of the United States Bureau of Public Roads to establish a basis for the design of concrete roads by means of a condition survey undoubtedly represents one of the prominent landmarks in the field of civil engineering. To lead the enterprise to final success requires methods of procedure which are fundamentally new as the methods recently developed in the hydraulic laboratories of Europe for solving the problems of river improvement and of hydro-electric power development. As far as their essentials are concerned their methods resemble those which have been successfully used in medicine much more closely than those which are customary in engineering. Putting these methods into practice, therefore, requires a thorough mental readjustment on the part of engineers engaged in the enterprise.

"The reason for the striking contrast between the high state of perfection of the semi-empirical methods of medicine and the rudimentary state of the same methods applied to foundation engineering is essentially psychological. The rapid development of modern engineering was due to obtaining accurate solutions of various problems by means of applied mechanics. As a consequence, theoretical treatment of engineering problems looked to be so promising and so attractive that almost all the productive brain power available was focused on applied mechanics; those problems which could not be approached from a theoretical standpoint were simply neglected. The result was that some branches of engineering were developed to the very limit of perfection, while others remained in a deplorably backward state. In medicine and in physiology there are no problems simple enough to be treated by means of applied mechanics; semi-empirical methods are the only ones which are apt to give results. Hence, from the very beginning, the men engaged in these fields had to choose between remaining on the general level of ignorance or developing methods for gradually approaching the truth by systematically reducing the importance of possible error. The remarkable success achieved in medicine and physiology is the best guarantee we have for ultimate success of semi-empirical methods in foundation engineering."[5]

In referring to foundation engineering, Dr. Terzaghi included pavement design. He could just as well have included traffic engineering, concrete and bituminous mix design, highway system planning and most of the other phases of road engineering. The ultimate success of the semi-empirical techniques referred to by Terzaghi was proven by the very experiment he referred to as a landmark in civil engineering. The now famous Westergaard formulas for concrete pavement design, which are still in use today, resulted from the concrete road condition surveys of the Bureau of Public Roads in the late 1920's. This technique of "systematically reducing the importance of possible error" is the basis of all road research today. It is a logical and rational basis of working and has produced results which form the basis of the present knowledge of the art.

Once the need for research in the United States was realized and the techniques for conducting it were established, there was a constantly increasing effort devoted to advancing road and street engineering science. Under the direction of Thomas H. Macdonald, the U.S. Bureau of Public Roads provided the leadership in road research both by undertaking numerous large projects on their own and by encouraging universities and highway departments to do likewise. The Bureau also provided financial and technical assistance for research undertaken by the State highway departments.

By the 1940's road research in the United States was a well-organized, highly-developed, co-ordinated effort. At the same time road research in Canada was just beginning. Perhaps the real beginning in this country dates from the work of Dr. Norman W. McLeod for the Department of Transport in developing a method of flexible pavement design for airports and highways at the end of World War II.[3] Since that time interest has increased substantially and road research projects have been undertaken in all provinces of Canada.

Up to the present we have had little knowledge of the extent of the total road research effort in Canada. Unfortunately, the results of much of the work which has been done were lost to the profession and industry as they were not published nor given proper distribution. Equally unfortunate has been the duplication of effort by researchers working independently on the same problems. That is why the Canadian Good Roads Association is working to do away with this waste of valuable time, effort and money. The problem has been attacked in three ways. Specialized technical sessions have been provided at the CGRA annual conventions where Canadian highway engineers can present papers for discussion and publication. Secondly, technical committees have been established to discuss current problems and exchange data. Lastly, a road research correlation service has been undertaken. Through the correlation service a survey of road and street research activities in Canada has been made and a book published detailing all current or recently completed projects together with information as to where results may be found. Subsequently, the results of this survey to date, the organization for research in Canada and the areas where research is apparently needed will be discussed.

Value of Road Research

The value of road research has been referred to. Before elaborating on this subject and citing more concrete examples, we should first define the meaning of research. Dr. McLeod has defined it as follows: "Highway research is . . . (the) search for *new knowledge* that is to be applied to the solution of given highway problems (and thus) does not include such routine activities as the testing of materials, traffic surveys, etc."[2]

Beyond this fundamental concept it is important to distinguish between "basic research" and "applied research". Although it is frequently difficult to delimit these areas of investigation, the following definitions may be useful in defining the concepts:

Basic Research—Through scientific study or critical investigation to discover fundamental facts pertaining to the laws governing the operation of a process in order to formulate, test and establish theories contributing to an understanding of that process.

Applied Research—Through study and investigation to effect immediate solutions to current problems or to bring about apparent improvements over existing conditions in the operation of a process or performance of a material. This would include the investigation or trial, or both, of new innovations in planning, design, construction, maintenance or administration techniques currently in use by a road department.

Both types of research are important but by far the greatest portion of road research can be classified as applied. CGRA's survey and correlation service includes both types and could well be termed research and development. Highway engineers are not only interested in hypotheses for the prediction of the migration of moisture in soils but also in improved methods for the compaction of bituminous mixtures in paving operations, for example.

The experience of others outside Canada proves that highway research pays off. In 1936 the State Department of Indiana, together with Purdue University, established a Joint Highway Research Project at the university. The staff of this project are professors and research engineers who teach postgraduate courses in highway engineering and conduct or supervise research work. This work is financed by an annual grant from the State Highway Commission which at present amounts to about $150,000 per year. In a progress report in 1950 Professor K. B. Woods, Director of the project, made the following statement:

"Summarizing the monetary benefits of highway research, it is apparent that any one of several completed studies is already paying dividends equal to the entire yearly cost of the annual highway research program. It is likewise apparent that the surface has only been scratched, and there is every reason to believe that the dividends will be much greater in the years to come than in the past."[7]

In support of this statement Professor Woods cites several specific examples including one finding which alone is estimated to be saving the Indiana State Highway Department between $100,000 and $200,000 a year.

Dr. W. H. Glanville, Director of Road Research, United Kingdom Department of Scientific and Industrial Research, indicated in 1954 that the work of his organization had probably resulted in savings that run into millions of pounds per annum.[1] Dr. Glanville also noted that" . . . a Select Committee of the House of Commons, charged with the task of reducing waste, recommended . . . (in 1953), as a measure of economy, the expenditure on research should be increased by 50%.

Many senior highway officials in Canada have long contended that it is foolish and wasteful to do road research in this country. They contend that the results of the large research programs in the United States are available to us without cost and it would thus be foolish for departments to waste the time of valuable engineers on such work. This theory has some merit but it is certainly far from being correct. It is true that we must utilize the work of the U.S. researchers to avoid unnecessary waste, but we must also do research work of our own. The reasons for this are obvious.

The results of applied research in a particular area are not always directly applicable in other regions. For example, after extensive laboratory and field investigations a state highway department may establish a new specification and test to eliminate the use of a poor performing material. The test would probably be empirical and would satisfactorily discriminate between good and bad materials for the sources of supply in that region. If a Canadian province blindly adopted that specification there is a possibility that it could exclude materials available in that province which have given excellent service. The reason, of course, is that the test was developed without studying these particular sources of supply. Before adopting the research results of a particular agency, we must thoroughly investigate them to determine if they are applicable in our own area.

A second reason why Canadians must do road research is that we have special problems of our own that urgently require solution. Our climate is more severe than that in either the United States or the United Kingdom. Our soils and locally available building materials may also be different. In these cases, to be practical and economical our design practices may have to be different. It is natural that we must investigate these unique problems and develop our own criteria. In other cases our most critical problems may be much less urgent in the United States and hence not receiving attention in that country. We must then do the work and supply the results to our neighbours.

A third reason for doing research in Canada is that such programs greatly aid in the development of our engineers and technicians. The research-conscious practising engineer is more likely to profit from the lessons of experience than the engineer who does not seek to learn the reasons behind observed phenomena. The university professor engaged in research is usually better informed and hence a better teacher. Road research in the universities will also increase the supply of graduate engineers for our highway departments and improve their quality.

In Canada we have the qualified engineers in our highway departments and universities to do this needed research. It is also apparent that these men know the problems requiring investigation. One has only to read the Proceedings of the Canadian Good Roads Association for the past two or three years to see this. These men need only the time, budget and encouragement to get on with the job.

CGRA'S Role in Research

Two of the basic aims of the Canadian Good Roads Association, as stated in its constitution, are:

1) To encourage the development and improvement of methods of planning, design, construction, maintenance, operation and administration of roads and streets in Canada;

2) To advocate the development of technical skills in all branches of the highway sciences through . . . dissemination of information.

The principal function of CGRA today is to serve as the co-ordinator of road and street research in Canada and as the clearing house for technical information in this field. The Engineering Institute of Canada and other national organizations should continue to publish and distribute articles on highway developments. They might even expand their efforts in this direction. However, the annual expenditures on roads and streets in Canada now exceed the one billion dollar mark. This is one of the largest industries in our country. It is therefore necessary to have one central agency devoted solely to this industry to collect and distribute all information on new developments and provide a forum for discussion and resolution of common problems. CGRA is a non-political, non-profit organization which provides the common meeting ground where technologists of both government and industry can contribute equally to the development of the highway sciences. In this regard, CGRA serves Canada as the Highway Research Board does the United States, or the Road Research Laboratory does the United Kingdom.

A brief look at the 1960 Organization Chart of the Canadian Good Roads Association will illustrate how these functions and objectives are discharged. The 25-member Board of Directors this year is under the chairmanship of our president, Hon. Fred M. Cass, Minister of Highways of Ontario. Members of the Board represent all segments of the Association's membership, which includes governments, industry and universities. The Operating Committee also has 25 members who are responsible to the Board of Directors for the implementation of its policies. The present chairman of this group is Mr. Norman H. Bell, President of The White Motor Company of Canada Limited. The Association has nine permanent staff members, including two engineers, working under our Managing Director Mr. C. W. Gilchrist.

The Joint Committee on Uniform Traffic Control Devices for Canada was convened by CGRA in May 1956 to produce a manual containing recommended standard signs, signals and pavement markings for all roads and streets in Canada. It is jointly sponsored by CGRA and the Canadian Section, Institute of Traffic Engineers, and includes representatives from each province, the major municipalities, the Government of Canada and interested national associations such as The Engineering Institute of Canada.

The new Manual, which has been published by and is available through CGRA, was introduced in September 1959 at the annual CGRA convention in Vancouver. Not only has this manual been adopted across Canada, but already the change-over to the new standards is taking place in all provinces.

The AASHO Road Test Observer Committee was authorized by CGRA's Operating Committee in 1955 to observe and report upon all phases of the $22 million road test being conducted at Ottawa, Illinois, by the American Association of State Highway Officials. This CGRA committee is responsible for the dissemination in Canada of all road test information. CGRA also has an engineer resident on the project and working with its staff on the research. This is an outstanding example of co-ordinating research to obtain the maximum benefits from the work of others. Our Observer Committee will endeavour to interpret for Canada and Canadian conditions the results of this project when it is completed in 1960.

The Technical Advisory Committee Information guides all technical activities of the Association. It is composed of 34 members who are the officers of each of the individual technical committees, plus six members-at-large and a chairman and vice-chairman appointed by the Operating Committee. Its present chairman is Dr. Norman W. McLeod, Asphalt Technologist, Imperial Oil Limited, while the vice-chairman is G. B. Williams, Chief Engineer, Development Enginering Branch, Department of Public Works, Ottawa.

The specialized technical committees — Bridges and Structures; Construction and Maintenance; Economics, Finance and Administration; Municipal Roads and Streets; Planning and Design; Safety Education; Soils and Materials; Special Committee on Pavement Design and Evaluation; Traffic and Operations—are each individually responsible for preparing and conducting a session at the annual convention of CGRA. These committees also undertake co-operative studies of current problems and prepare reports for publication. The committees are also free to call upon the Association staff for assistance or to recommend staff undertakings. As a result of committee work, the secretariat of the Association is working with the Dominion Bureau of Statistics to establish a continuing road price index for Canada; it is compiling a bilingual dictionary or glossary of standard road and street terminology; and has completed two annual surveys of highway department engineers' salaries. All the projects under way or completed by the committees are too numerous to describe in this report. However, mention must be made of two of the more important projects currently under way. One is an intensive co-operative study of pavement performance by ten provincial and two federal government departments, which has been in progress for about one year and is designed to develop methods for designing new pavements and evaluating the carrying capacity of existing pavements. The second project is an undertaking of the Committee on Planning and Design in which between fifty and one hundred engineers from every province will participate. Its purpose is to develop a manual of geometric design standards for roads and streets. Having just officially started, it is anticipated that this manual will not be completed until 1962.

CGRA has over 700 sustaining members. This year's convention, which was held in Vancouver in September, attracted over 1,200 delegates, including several hundred highway engineers, administrators and economists. More than 70 authorities presented technical papers or participated in panel discussions in the nine technical and three general sessions. The three-day convention was preceded by two days of committee meetings. Such a conference provides the best possible opportunity for the exchange of technical information and for the presentation and discussion of papers on Canadian road research.

Road Research Survey

The purposes of the CGRA road research survey and correlation service are four in number. They are:

1) To acquaint practising highway engineers with new findings so that research results can be incorporated into current practice with the least possible delay;

2) To acquaint research workers with other activities parallel or allied to their own investigations, thus avoiding unnecessary and costly duplication of effort;

3) To expose those areas of ignorance which urgently require study and investigation;

4) To stimulate and enlist support for the research efforts of the roads departments, universities and industry.

In the initial survey over 100 agencies in Canada were contacted, comprising all major universities, consulting engineering firms and industries as well as the appropriate departments of all levels of government. With the questionnaire a tentative subject classification was provided and each agency was requested to supply a brief report for each separate project in their research program. The information which was requested for all current projects, as well as those completed within the last five years, included: subject classification, title of project, brief description of scope of work, estimated expenditure in 1958, location of the work, names of the investigating staff, starting and completion dates, and where interim of final reports of results are published or are available. Supplementing the questionnaire replies with staff investigation, a complete descriptive listing of all Canadian road research projects, classified by subject, has been published.[4]

Considerably more than half of the agencies contacted reported research programs. The publication, although known to be incomplete, contains data on 159 individual projects. The returns from the questionnaires also indicate that approximately $1 million was spent in 1958 in Canada on road and street research and development.

These estimates mean that for every $1,000 invested in roads and streets in Canada in 1958, one dollar was spent on research and development. This means that in Canada we are spending on road research about one-tenth of one per cent of our total appropriation for highway construction and maintenance. It was reported that in the United States in 1951 about one-fifth of one per cent of road expenditures was allotted to research.[2] This has undoubtedly increased over the last seven years. Thus, the rate of expenditure for road research in the United States is more than double the rate in Canada. Compared to industry, where as much as two per cent of the total income is invested in research and development, our road and street research effort is pitifully small.

Although the road research effort in Canada is obviously inadequate, the scope and volume of the work as compared with but a few years ago is most encouraging. The projects reported to date cover many phases of the highway science such as soils and materials; traffic engineering; economics, finance and administration; planning; design and bridges. However, it is important to note that highway engineering overlaps other branches of science and engineering. Thus, our survey includes research work being done by such agencies as the federal Department of Transport, the Prairie Farm Rehabilitation Administration, and the Ontario Department of Transport. The only work of these agencies which has been included in our compilation is that which has direct application to highway technology. Deducting from our compilation the contribution to road research by such outside groups as those just noted, it becomes apparent that the amount of research either done directly by the highway departments or sponsored by them in the universities is extremely small for the size of the organization, the volume of work done and the opportunity for doing research conveniently and cheaply.

Organization for Research

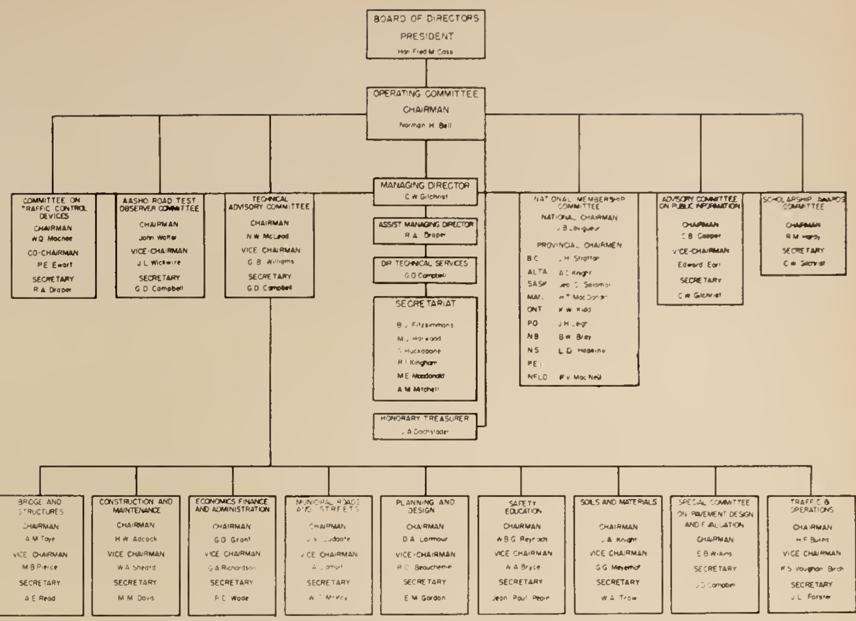
A pattern for the organization of highway research in Canada was presented to the 1955 convention of the Canadian Good Roads Association by Dr. Norman W. McLeod.[2] In this paper Dr. McLeod envisaged an expansion of research in the highway departments and universities, a greater contribution from industry, and a leading role for the Highways Division of the federal Department of Public Works. He saw for this federal government department an opportunity to stimulate and assist research in the smaller provinces, to co-ordinate work nationally and internationally, to develop good relations and a co-operative spirit in research with the provincial departments and among them, and to act as a central storehouse for data obtained from highway engineering research and investigation in every part of Canada. He also urged the development of joint highway research projects similar to those operating in the United States, where the provincial departments finance road research in their provincial universities. Finally, he recommended support for the Canadian Good Roads Association and its technical committees as a means of co-ordinating research; presenting, publishing and distributing technical papers; and discussing common problems.

With one exception these recommendations are gradually becoming a reality. Interest in road and street research in the highway departments has increased. The Ontario Department of Highways has joined with Queen's University and the University of Toronto in creating a fine, active Joint Highway Research Project. A similar undertaking has been established at the University of Alberta with the support of the provincial Department of Highways. The work of CGRA has increased tremendously in the past three or four years, while other agencies are also increasing their road research work. The federal Highways Division has shown considerable interest in road research and has supported the work of CGRA, but to date it has not undertaken any significant research program nor has it assumed a major role in such activities. Although the federal government does contribute to road research through the work of the Department of Transport in developing airport pavement design and construction techniques, through the National Research Council in its basic research on soil mechanics and frost action in building construction, and the Dominion Bureau of Statistics in assembling the facts for transport analyses, it is indeed unfortunate that our national government has not undertaken a more substantial road research program through the Highways Division of the Department of Public Works.

The pattern for road and street research in Canada as it is evolving today is undoubtedly the most effective way of getting the job done. Centralize the discussion, provide a central clearing house for the exchange of data and results, but keep the actual work and the workers dispersed over the entire country. The cheapest and most effective way to get results is to make every engineer a researcher and every construction project an experiment and every highway system a laboratory.

Needed Research

Road and street engineering is no longer an exercise in surveying. Today it is necessary to establish the traffic potential of a route and evaluate its economic justification and relative priority. Geometric design standards must be established for the facility in accordance with the predicted usage during its life. Soil surveys must be made and aggregates sources located and evaluated before the structural design of the road can be determined. The plans and specifications have to be adapted to the materials available. Traffic control devices must be planned and designed, while roadside development can no longer be ignored or neglected. The need for such elaborate planning and complex design has been with us less than 30 years. Many of the factors contributing to the problem are of much more recent origin. It is little wonder that the science of highway engineering is in such dire need of fundamental research and development.



Canadian Good Roads Association — Organization Chart, 1960

Today, satisfactory design techniques for determining the thickness requirements of either flexible or rigid pavements under varying soil and climatic conditions, road usage and axle loadings have not been developed. The currently used tests and specifications for selecting satisfactory aggregates for concrete and bituminous mixtures are far from perfect. In the field of soil mechanics, knowledge of shear strength evaluation is, to say the least, imperfect and the methods of embankment and slope stability analysis are still crude. The mechanics of frost action in soils are not fully understood and the design criteria for preventing frost damage to pavements and structures leave much to be desired. Traffic engineering as a science is still in its infancy. Research is badly needed to develop traffic volume warrants for various road design features. Traffic survey techniques must be simplified and improved to increase their effectiveness and the reliability of results.

These are but a few of the problems of the highway engineer where research and investigation are urgently required. The annual bill for patching inadequately designed or constructed pavements and the economic waste of unnecessary congestion and traffic accidents are strong evidence that such research cannot fail to save the people of Canada large sums of money annually.

Our research survey shows that Canadian agencies are making efforts to solve those problems cited. However, the survey also shows that one of the most important aspects of road and street development has received very little attention. The social and economic effects of highway improvements should receive as much study as the problems of developing improved construction materials or traffic control devices. It is imperative to scientifically assess the over-all purpose and objective in building roads and streets and determine if our plans will ultimately achieve these goals. In the past, many of the major road improvements have become a liability to the community and to the province because, through inadequate planning, they bred accidents, congestion and roadside slums. Rural highway development has been emphasized to

(Continued on page 62)

EDMONTON INSTALLS CANADA'S FIRST OIL-FILLED PIPE CABLE SYSTEM

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

In 1957, the City of Edmonton placed in operation the first extra high voltage Oil-Filled Pipe Cable System in Canada. The system was expanded with a second installation in 1958.

This paper describes the system, the design of cable and accessories, the installation and the acceptance testing. Service experience to date is discussed and reference is made to operating conditions and maintenance procedures.

Introduction

In 1957, the City of Edmonton placed in operation the first extra high voltage underground Oil-Filled Pipe Cable in Canada. In 1958, a second installation of Oil-Filled Pipe Cable was completed and further expansion of the 72 kv. underground system will take place as load growth requires it.

Edmonton's Power Utility consists of two departments which are fully owned and operated by the City. The City Power Plant generates all power requirements for the City. The Electric Light and Power Department purchases power at the Power Plant bus and carries out all transmission and distribution of this power from the Power Plant to the customer.

In 1956, increasing load led to plans for expansion — a new power generating station to double or triple the system capacity and a revised distribution system to take care of expanding future requirements.

Until 1956, the highest voltage used for transmission in the City was 13,800 volts. The duct lines, cable system and aerial system had been designed to accommodate the total capacity available in the existing Power Plant. With the advent of an expanded Power Plant, it was necessary to study the most economical means of distributing this power throughout a city which was rapidly expanding. Economic studies indicated the voltage level should be 72,000 volts. The location of the Power Plant in the centre of the city dictated that the 72 kv. system, radiating from the new Power Plant, should be underground cable. (Fig. 1)

The Electric Light and Power Department engineers studied the various types of underground cable systems, including oil-filled cable in ducts, directly buried armoured oil-filled cable, directly buried gas compression pipe cable and oil-filled pipe cable. A decision was made to install the oil-filled pipe cable system, because it combined rugged construction with the lowest installed cost.

The first circuit, placed in operation in 1957, ran between the Power Plant and the Namao Substation, a distance of 22,000 ft., with a 1,500 ft. tie-line between the Power Plant and the Calgary Power System. The second circuit, completed in 1958, ran between the Power Plant and the Strathcona Bulk Station, a distance of 17,695 ft.

The Oil-filled Pipe Cable System

The system consists of three single conductor solid type paper-insulated cables drawn into a corrosion protected steel pipe which is filled with insulating oil automatically maintained at high pressure by a pumping plant. (Fig. 2)

All joints are made in manholes and the joint casings welded to the steel pipe to form a continuous pressure-tight system. The cables are brought out to the terminals through either a spreader head or a trifurcating arrangement. The oil in the potheads is subjected to the same high pressure as the oil in the pipe. The complete system is generally provided with cathodic protection.

The System Requirements

The City of Edmonton's specifications were specific without being restrictive. The major requirements were as noted below:

1. The cable to be either Oil or Gas-Filled and in accordance with the requirements of the applicable AEIC or CSA specification. Conductors to be either copper or aluminum. Protective covering over the cable sheath to be provided for prevention of electrolytic corrosion, and cathodic protection to be used.

2. The potheads to meet the requirements of "Standard for Potheads" AIEE No. 48 January, 1948.

3. Service Conditions
Circuit Voltage: 72 kv. — 3 phase — 60 cps
System Neutral: Grounded
Basic Impulse Level: 350 kv. for cable; 450 kv. for potheads
Ampacity: 482 amperes continu-

ously with one two-hour peak of 642 amperes during a 24-hour period
Symmetrical Short Circuit: RMS current 25,000 amperes max. — 10 cps clearing time
Soil Resistivity: 80 thermal ohms per watt per centimeter cube
Soil Ambient: Winter — 20F; Summer — 68F

4. The installation to be acceptance tested with d-c voltage after completion of the installation.

5. The manufacturer to design, manufacture, test, supply, deliver, install, place in successful operation and guarantee the cable, potheads and associated accessories.

The System Components

The Cables. The cables were manufactured and tested in accordance with the Association of Edison Illuminating Companies Specifications for Impregnated Paper-Insulated Cable, High-Pressure Pipe-Type. Fig. 3. shows the details of the cable. The conductors were 650,000 circular mil stranded copper. The ampacity, based on the installation conditions, is 650 amperes at a load factor of 77.15%. In one section where the cable run was situated on a steep slope with a maximum grade of 35%, each insulated conductor was armoured with No. 6 AWG 57-SH aluminum alloy armour wires which were clamped at the splice at the top of the slope to prevent movement of the cables and the splice due to ratcheting of the cables under load cycles. Because of the increased losses due to the armour wires, it was necessary to increase the conductor size to 850,000 circular mils in this section.

The conductor shielding consisted of three metallized paper tapes. The insulation was a 0.295-in. wall of density graded paper using three densities of paper tape. The insulation shielding consisted of a combination of metallized paper, aluminum-mylar and bronze tapes.

A D-shaped brass skid wire 0.1 by 0.2 in. was applied in an open spiral around the completed conductor to support the cable during pulling-in operations.

The Pipe. The pipe used was electric-resistance welded steel pipe, Grade A, per American Petroleum Institute (API) Standard 5-L, 15th Edition, March, 1956. The outside diameter of the pipe was 5-9/16 in. and the wall thickness, 0.258 in.

The interior of the pipe was cleaned and treated with a preservative compound compatible with the insulating oil used in the system.

The outside of the pipe was corrosion protected as follows:

1. Shotblasted and primed with coal tar;
2. 3/32-in. coal tar enamel;
3. Two wraps of fiberglass tape (0.018 - 0.020 in. thick);
4. 1/16 in. plasticized coal tar enamel;
5. One wrap of 15-lb coal tar impregnated asbestos pipeline felt;
6. One wrap of 80-lb kraft paper.

The corrosion protection on each length of pipe was tested at 15,000 volts at the time of manufacture.

The Manholes. Reinforced concrete traffic manholes were constructed for all straight-through joints and for two terminal joints. Manhole inside dimensions were 14 x 5 x 6 ft. A wall thickness of 8 in., a ceiling thickness of 12 in. and a floor thickness of 6 in. of 3,000 p.s.i. reinforced concrete was used throughout.

The Splices. The straight-through splices (Fig. 4) were 50¾ in. overall.

The conductors were joined together with a copper sleeve using four compression indents. After compression, the indents were filled with solder and the connector rounded off

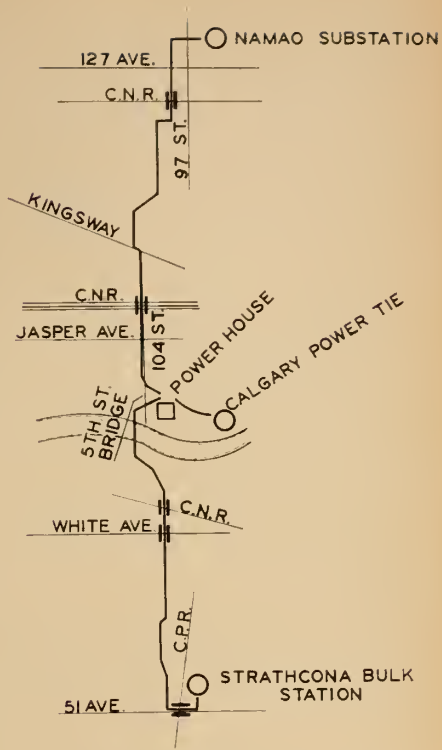
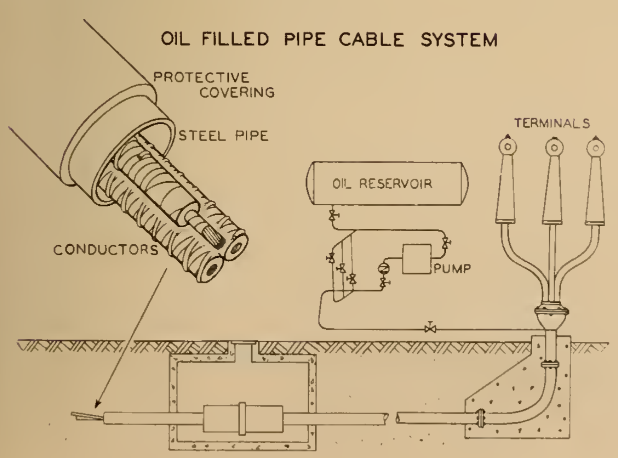
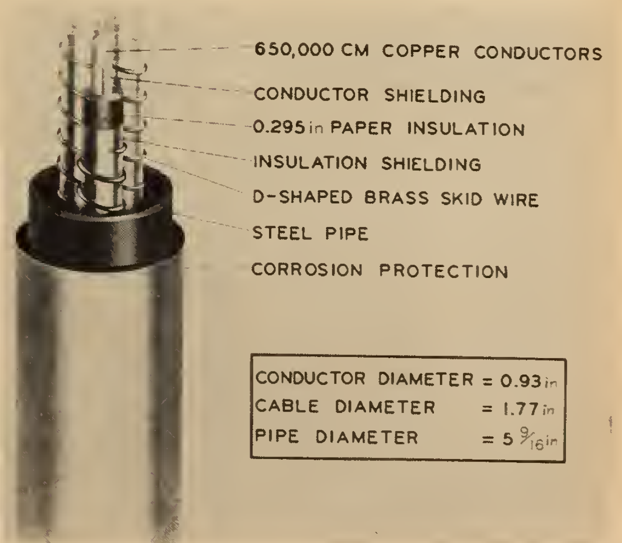


Fig. 1. Location of Namao and Strathcona Circuits and Calgary Power Tie

Fig. 2 below—Oil Filled Pipe Cable System

Fig. 3 right—Oil Filled Pipe Cable





with rounding dies. The factory insulation was stepped in ⅛-in. steps and oil impregnated crepe paper insulation applied by hand to the required dimensions. To apply the shielding, three perforated grounding strips were spaced 120° around the joint. Copper braid shield tapes were applied half-lap over the grounding strips and held in place by the pointed perforations. When the shielding was completely applied, the perforations were pressed down.

When the three phases were spliced, two aluminum spiders were placed near the centre of the joint and the assembly bound together with cotton webbing.

The skid wires were soldered to the shielding tapes and after providing slack, were secured to the pipe reducer.

The steel sleeves were slid into position and welded at the centre and at the reducers. The spiders rest on the sleeve and centre the joints in the sleeve.

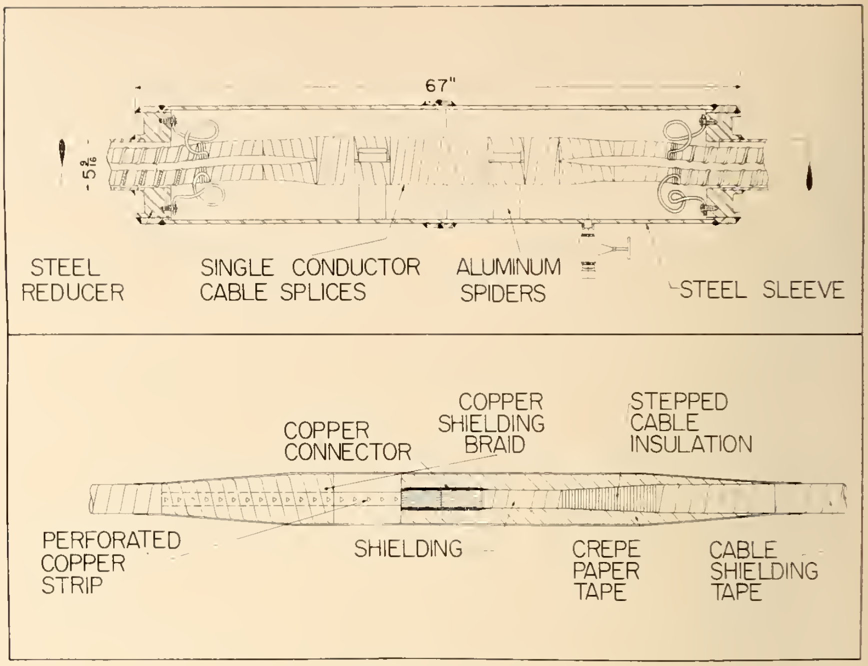


Fig. 4. Oil-Filled Pipe Cable Splice and Splice Assembly

The Terminals. Depending on the pulling conditions and location of the terminals in relation to the pipe line, two methods of terminating the line were employed.

One method used (Fig. 5) was the spreader head. The line pipe was brought above ground in a 7-ft. radius bend and anchored in a poured concrete block which formed part of the tower footings. A spreader head was welded to the pipe. Three copper riser pipes joined the spreader head to the potheads.

The second method (Fig. 6) made use of a manhole at the termination of the line. A trifurcating joint was made in the terminal manhole similar to a straight-through joint, except that one end consisted of a manifold assembly where three copper riser pipes from the potheads were connected to the splice sleeve.

The Potheads. The potheads used were single conductor, 92,000 volt, 200-p.s.i. oil pressure potheads. The terminal stalk was compressed on the conductor in the same manner as the splice connector. Where the insulated conductor passed through the semi-stop plate, a semi-stop feature was incorporated using a gasket which was compressed against the insulated conductor. To compensate for pressure variation in the pipe and in the pothead, eight Alemite pressure fittings were located in the semi-stop plate between the ground plate and the pothead body flange, four for outgoing and four for incoming pressure.

The stress relief cone was built up from a paper roll made from high quality paper, dried and impregnated in the same manner as the cable. The stress cone was shaped manually by rotating and pulling out the paper roll to predetermined dimensions.

After the application of the shielding tapes, a 16-in. stress control tube was located above the stress cone. The porcelain assembly was finally placed and bolted through the semi-stop plate to the ground plate.

The Pressure Control Centre. The pressure control centre is in a pump house approximately 100 ft. from the switchyard terminal structure.

The pump house, designed and constructed by the City, can be heated to a minimum of 60°F under the worst weather conditions to ensure satisfactory operation of equipment.

The control centre is an automatic dual pumping system designed to maintain the pipe oil pressure between 180 and 220 p.s.i. with provision for operation at reduced pressure during installation and maintenance periods.

It consists of the following units.

Oil Storage Tank

Oil is maintained under a positive pressure of dry nitrogen gas in a 4000-gallon (U.S.) storage tank. This storage provides the oil necessary to compensate for volume changes in the main pipe line.

Oil Pumps

Sealed gear oil pumps rated at 5.5 US gpm maintain oil pressure in the pipe by drawing oil from the storage tank and pumping it into the pipe system.

Automatic Pressure Relief Control Devices

These devices provide a fully automatic means for removing the oil from the pipe line. They prevent excessive line pressure by means of automatic mechanical and electromagnetic relief valves by passing oil from the pipe into the storage tank. The valves are mounted in parallel with the oil pumps and are set to open and close at predetermined oil pressures.

Recording Gauges

Recording gauges provide a complete and continuous record of oil pressure in the system. The recorders are mounted in the instrument panel and cover a seven-day period.

Alarm System

Comprehensive alarm circuits are designed to protect the system. The alarm system with a fourteen-lamp annunciator gives visual indication of faulty operating conditions and can be connected to a remote location.

The capacity of the storage tank

and pumps was designed to provide for the installation of an additional circuit. Connection of the control centre to the line was made by the same corrosion protected pipe used for the cable line. The connection was made in the terminating manholes at the switch-yard by means of a valve provided in the splice casings.

The Oil. The oil used to fill the pipe after installing the cable was a high grade, low viscosity type similar to the cable impregnant. Under the most severe condition of suddenly applying the full load of 642 amperes to the cable, which had been idle in mid-winter for a sufficient period to reach the minimum earth temperature of 20°F, the maximum transient pressure rise would be 255 p.s.i. at the Namao Substation end of that circuit. The pipe, potheads and other components were designed to withstand this pressure rise.

Cathodic Protection. The cathodic protection of the carrier pipe consisted of a rectifier as a source of current and a low impedance cell installed on each end of the cable circuit. The cell was located in the ground return at each end of the cable circuit, maintaining a negative potential on the pipe, and at the same time, enabling the cable circuit to be adequately grounded through its low impedance.

Installation

The system was installed by the manufacturer who sub-contracted the installation work. The manufacturer had, at all times, an installation engineer on site to provide technical direction to the contractor and to ensure that the installation was in accordance with specifications and requirements. The City of Edmonton also had an engineer on site to coordinate the installation with various associated aspects such as the survey of right-of-way and grades, parking restrictions, traffic control, repairing of trenches and inspection for adherence to specifications.

Although the system is rugged, particular care was taken in the handling of raw materials. Corrosion protected pipe was blocked and padded to prevent movement and abrasion of the covering during rail shipment. The pipe was handled at all times with wide canvas slings or from the ends, and supported on skids or sandbags during installation.

Particular skills required in the installation were welding and splicing. All welders were required to qualify as prescribed in API Specification No. 1104 "Standard for Field Welding of Pipe Lines". All splicers were required to qualify by completing a splice in a splicing school to the manufacturer's requirements prior to the installation of cable.

Pipe. The pipe was installed with a minimum coverage of 4 feet. It was placed on a 3-in. bed of sand and backfilled so that a minimum of 3 in. of sand surrounded the pipe in all directions. In areas where the excavated material was unsuitable for backfill, being in the nature of cinders, ashes and such, the backfill used was screened sand for at least 1 ft. in all directions from the pipe. The trench was graded to allow the pipe to lay of its own accord without field bending wherever obstructions or services were encountered.

Pipe sections were welded together using chill rings to prevent the formation of weld icicles on the inside of the pipe. All welds were tested by radiographic inspection against the API Specification Standard No. 1104. The film of each weld was examined before the pipe weld was approved.

After welding, all joints were corrosion protected. A fibre mould was strapped around the weld section and filled with pipe enamel. The mould was left as part of the joint protection.

Prior to laying the pipe in the trench in its final location, the pipe coating and all joints were tested at 15,000 volts to ensure that the coating was undamaged. The pipe was laid in the trench starting at one manhole and working to the next manhole. The backfill was then thoroughly tamped in place.

Pipe Testing and Treating. When each manhole section of pipe was completed, the reducers were welded to the pipe in the manhole. A *mouse* was blown through the section to ensure cleanliness. Test caps were fitted to the pipe and a 24-hour pressure test made at 100 psi using high purity nitrogen (99.99% N_2 and 0.01% O_2, dew point -60C). Each section was evacuated to an absolute

Fig. 5. Spreader Head Termination

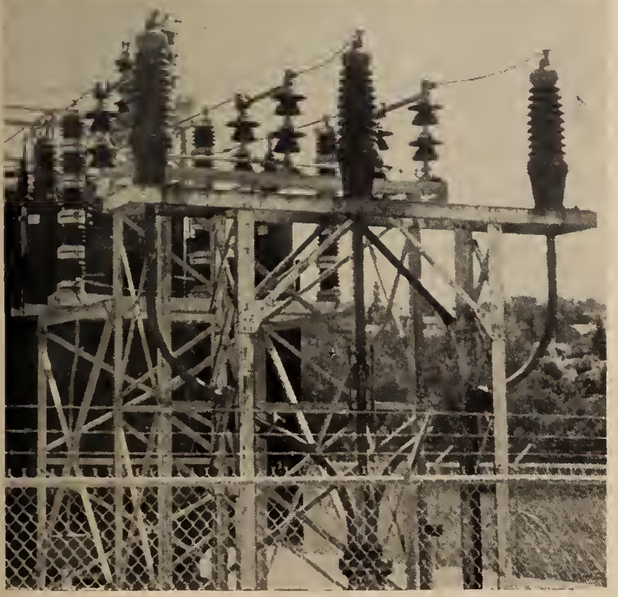


Fig. 6. Trifurcating Termination

pressure of 100 microns of Hg or less and to a maximum pressure rise of 50 microns of Hg in one hour. The vacuum was then broken by admitting high purity nitrogen until a positive pressure of 10 p.s.i. was obtained. The pipe ends were sealed in such a way that this pressure was maintained until cable was pulled.

Casing Pipe. In four sections, the cable pipe passed under railway lines and was enclosed in casing pipe to meet the requirements of the Board of Transport Commissioners for Canada. In another section, where a subway crossing is planned for the future, the pipe was set at a depth of 25 ft. and the line below the proposed crossing cased as an added precaution. The cased sections for the single-line railway and subway crossings were 100 ft. For the main-line C.N.R. crossing and the C.N.R. freight yard cased sections were 534 and 1188 ft. respectively.

The casing pipe was installed by boring, tunnelling and trenching. The cable pipe was pulled into the casing pipe and supported 1¼ to 2 in. from the casing pipe by pipe supporting insulators. The insulators were either prefabricated and strapped to the cable pipe or moulded around it at 10 to 12-ft. intervals. To ensure good thermal conductivity, the space between the pipes was completely filled with sand introduced in the form of a sand slurry.

Submarine Crossing. Where the Strathcona Bulk Station circuit crossed the North Saskatchewan River, a distance of 800 ft., special pipe installation techniques were required. The cable pipe was laid out on shore and welded into two 400-ft. lengths. Each length was coated with two layers of concrete, each a minimum of ½-in. in thickness, with a reinforcing mesh of 18-gauge steel wire between the layers. The concrete protection added extra weight to anchor the cable firmly in the river bottom and protected the corrosion protection from mechanical damage during installation. A trench was dredged in the river bed to a minimum depth of 3½ ft. and the concrete encased pipe was pulled into the trench. The two 400-ft. lengths were welded together during the pulling operation. The maximum pulling tension was approximately 20,000 lb.

Cable Installation. Prior to pulling cable, the splicing sleeves were slipped over the reducers. A manhole blower was used at all times to remove any nitrogen present in the manhole. A 1¼-in. threading cable was blown through the pipe with a special *mouse* designed to lubricate the inside of the pipe. This cable was used to pull a ¾-in. steel winch cable into the pipe for pulling the insulated conductors.

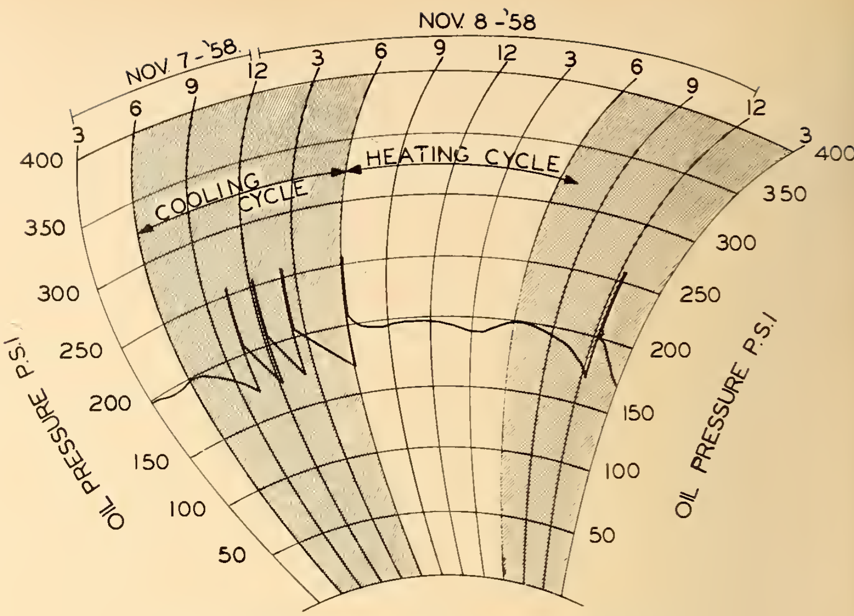


Fig. 7. Typical Section of a Pressure Record Chart

For each pull, three reels of cable were set up in tandem in line with the pipe run. A temporary tent of polyethylene was erected over the cable reels and the feed-in tube to protect the insulated conductors from moisture in the event of a sudden change of weather. Three cables were pulled into the pipe at one time. A continuous flow of dry nitrogen through the pipe was maintained. The cable was cut allowing sufficient cable at the reducer for the joint to be made. The cable extending beyond the reducer was enclosed in a metal night cap bolted to the reducer.

After pulling, each section of pipe was evacuated to a pressure of 1000 microns of Hg or less. The vacuum was broken with dry nitrogen gas and a pressure of 5 p.s.i. applied. The cable was left in this manner until splicing operations were carried out.

Pulling lengths on the Namao circuit were from 853 to 2475 ft. with an average pull of 1870 ft. The maximum pulling tension was 8270 lb.

On the Strathcona circuit, lengths ran from 2137 to 3203 ft. with an average pull of 2532 ft. Maximum pulling tension was 8000 lb. This occurred on a 2410-ft. pull incorporating five pipe bends.

It is of interest that the average pulling tensions on the second installation were 20 to 30% below calculated values. This reduction is believed due to the thorough lubrication of the pipe at the time of blowing the *mouse*, confirmed by the reduced wear of the skid wires observed.

At the terminals where a spreader head was used, the cable was fed into the 90° pipe bend at the termination. Sufficient cable was left at the give-up end to thread through the copper riser pipes. During this phase the cables were carefully supported. As each phase was completed, it was sealed with a pothead night cap.

Where a trifurcating termination was used, the copper riser pipes were installed from the trifurcating manhole to the pothead body flange and the required lengths of cable were pulled through the riser pipes. Night caps were installed at the reducer in the manhole and at the pothead.

Cable Jointing and Potheading. Cable splices and potheads were made under strictly controlled conditions and in accordance with reference drawings. Because it is of prime importance that moisture be excluded from the cable, splicers were provided with special gloves if their hands were moist or perspiring, portable air-conditioners were used to control the humidity in the manholes during splicing, and a tent was used to enclose the terminal structure during potheading.

The average time required for a splicer and his helper to complete a splice was 8 hours. To weld the joint sleeves into place took an average of 5 hours. Welding was done slowly to prevent overheating of the splice.

Two splicers and one helper required approximately 8 hours to complete two potheads. One splicer and helper required approximately 6 hours to complete one pothead.

Line Evacuating and Filling. When all joints and terminations were completed and the piping from the Pressure Control Centre connected to the line, the complete system was evacuated in approximately 30 hours to a pressure of 250 to 500 microns of Hg. This ensured that the line was dry and ready for oil filling. The vacuum pump was left on the line at the high end and oil was pumped into the system through a continuous degasifier at the pumping plant. Oil samples taken periodically from the output of the degasifier gave average breakdown values of 42 kv., assuring complete freedom from moisture and air. Average oil input was 150 gal. per hour and each line required approximately 75 hours to fill. At the completion of filling, approximately 10 gal. of oil was bled from each terminal top. The Pressure Control Centre was cut in to maintain 200 p.s.i. oil pressure and the degasifier disconnected from the line.

Acceptance Testing. The completed circuits were d-c voltage tested before energizing the lines. In the Namao circuit, 127.5 kv. d-c was applied for 4 hours. In the Strathcona circuit, a test set of higher output was used and the test voltage was 170 kv. d-c for 15 minutes. These tests are considered to be equivalent.

Cathodic Protection. After allowing the backfill to settle around the pipe line for approximately a month, a potential survey was made to determine the condition of the pipe coating and the requirements for cathodic protection. Tests showed that the average protective current requirements were in the order of 0.025 ma. per sq. ft. to provide a maximum negative pipe-to-soil potential of from 1 to 1.5 volts. Graphite anodes surrounded by coke breeze were installed as the ground beds at the Namao and Strathcona substations and at the switchyard. Three rectifiers were used, one at each substation and one at the pump house. A low impedance cell, consisting of a magnesium anode immersed in a salt solution, was installed in parallel with each rectifier to bypass the rectifiers in case of fault current on the pipe.

Operating Experience and Practices

Since the first circuit was energized in 1957, no difficulties have been experienced in its operation.

Supervision of the pipe line operation and routine maintenance are simple procedures. Once a week, a visit is made to the pumping station and the recording charts are changed.

Each week the pumps are rotated in operation so that they operate on alternate weeks, and a check is made of the nitrogen pressure and oil volume in the reservoir tank. At this time a visual inspection of the interconnecting piping is made at both the Pump House and the Substation terminals of the pipe line. Since energizing the cable, the load carried by the system has been as high as 40,000 kva. There has not been sufficient change in temperature to plot temperature rise against loading. Between light loading and heavy loading on the cable the oil transfer from the pipe to the reservoir and vice-versa is about 100 gal.

Along with the weekly check of the oil pumping and pressure system, a check is made of the cathodic protection. This check consists of measurements of the magnitude and direction of the magnesium cell current and rectifier output. The rectifier is adjusted to permit a current flow through the magnesium cell from the pipe of not over 0.2 amperes. Once the rectifier has been set to permit proper current leakage through the magnesium cell, no further adjustment is required unless a breakdown in the corrosion protection on the pipe changes the relative magnitudes of currents through the rectifier and the magnesium cell.

Fig. 10 shows a typical section of a pressure record chart taken from the week of November 3rd, 1958.

Nov. 7: 7 p.m. to 10 p.m.
as load drops, the line cools and the oil pressure drops to 170 p.s.i.

Nov. 7: 10 p.m. to Nov. 8: 6 a.m.
the control centre pumps oil into the line and brings pressure from 170 p.s.i. to 250 p.s.i. four times.

Nov. 8: 6 a.m. to 7 p.m.
as the load builds up, line pressure tends to increase due to temperature rise and oil is fed into the storage tank through the control centre bypass valves to maintain approximately 200 p.s.i. line pressure.

Nov. 8: 7 p.m. to 12 p.m.
as load drops, the line cools and the cycle repeats.

In the design of the system, a decision regarding the mechanical protection had to be made. For economic reasons, the decision was in favor of a heavy-wall steel pipe type cable instead of a standard concrete-encased duct line, or buried cable with mechanical protection consisting of concrete block slabs laid end-to-end above the cable for the full length of the cable route. The wisdom of deciding upon the steel pipe encasement was demonstrated recently. A power-take-off-driven boring machine engaged in drilling holes for steel poles, drilled a hole above the pipe and continued downward until it came in contact with the pipe. The wrapping which provides corrosion protection was considerably damaged and the steel pipe was scored. A hole was excavated around the pipe for examination and repair. The scoring did not extend deep enough into the steel to necessitate patching the pipe. Tape was wrapped around the pipe to repair the damaged corrosion protection and the hole was refilled. Those connected with the boring machine operations believe that, if this had been a buried cable installation, the powerful machine would have gone through the layer of concrete slabs and into the cable. On several other occasions, Utilities crossing the pipe with trenches, damaged the layer of corrosion protection with trenching equipment. In each case, it was only necessary to repair the corrosion protection by the application of tapes.

Conclusion

An Oil-Filled Pipe Cable system was chosen by the City of Edmonton as an economical and efficient means of reliably transmitting large blocks of power at 72,000 volts. The success of these first installations in Canada corroborates the wide experience with this type of cable in the United States and elsewhere, and indicates that it will find increasing use in Canada. A new installation in the City of Regina will provide an important power link which will be energized about September of this year.

GEOLOGICAL FEATURES AND FOUNDATION TREATMENT AT THE BEECHWOOD DEVELOPMENT

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

The Beechwood Development of The New Brunswick Electric Power Commission is located on a north-south reach of the St. John River slightly over one hundred miles north of the City of Fredericton. The international boundary parallels the river in this section and lies some eight miles to the west. The Development was undertaken to supply power which is fed into the provincial transmission line network. Two units consisting of Kaplan type turbines rated at 45,000 h.p. at a net head of 57 ft., together with associated generators and other electrical equipment, have been installed. Provision has been made for a third unit. The structures consist of gravity type concrete sluice and regulating sections, a fishway, an intake and powerhouse, a gravity type western abutment with a compacted earth embankment at the eastern end. The maximum height of structures above rock is 80 ft. and the overall length is about 1,750 ft.

St. John River Basin Physiography

NEAR THE HEADWATERS of the St. John River and its tributaries in Maine and Quebec, there are frequent bogs and swamps with lakes and ponds dotting the flatter areas. Much of this territory is relatively unexplored. In the Grand Falls area, the upland surface is dissected by steep sided valleys. Below Grand Falls, the slopes of the valleys and ridges become flatter and the drainage system is well developed with few lakes and bogs. Relief is variable through this region, in general being up to 1,000 ft. in the upper reaches near Grand Falls and in the order of 500 to 600 ft. in the Beechwood-Woodstock areas. From Woodstock to Fredericton there is a less well developed drainage pattern with numerous bogs and lakes. Local variations in relief may exceed 1,000 ft. Below Fredericton, the central plain of New Brunswick is an area of low relief extending down river to Hampstead. From here to the mouth of the river at St. John, the topography is rugged with a series of north-easterly-trending valleys and ridges. Relief may exceed 500 ft. in relatively short distances in this section.

The relief in this basin is controlled to a major extent by the bedrock type. Where the weaker sedimentary rocks occur, the relief is low, whereas in the areas where there are more resistant igneous and older metamorphic rocks, the relief varies to a greater extent.

At Beechwood, it is rolling country with occasional high hills that are indicative of igneous rocks that have intruded the sediments.

A major portion of the watershed is tree covered. In New Brunswick, the cultivated land tends to follow the valley of the river and its main tributaries. The soil is rich and this region is famous for its potatoes, amongst other crops.

Overburden

The major part of the overburden in the basin is of glacial origin, and the composition of the mantle of till usually indicates the type of underlying bedrock or the bedrock lying a short distance to the north-west. Silty till is found in areas where the bedrock is shale or argillite and a sandy till or sandy bouldery till where the bedrock is sandstone or granite.

On the hillsides, the till is generally only a few feet thick and on the steeper slopes, is practically non-existent. As one descends from the ridges, berms of thicker till are found on either or both sides of the majority of the valleys. Further down near or in the valley bottoms of the major streams, deltaic or outwash deposits of poorly stratified sands and gravels frequently occur. Silt deposits were formed in portions of the main valleys as a result of glacial damming, and marine clays have been identified in the southern portion of the basin.

Bedrock

The major portion of the bedrock of the basin is of sedimentary origin, probably of Silurian age; it consists of shales, calcareous shales, limestones and some sandstones. Much of the area has been subjected to intensive folding and the consequent development of cleavage in the shales has been such that, in some sections including the Beechwood area, evidence of bedding has been well nigh destroyed. Some of these shales grade into a poor quality slate or argillite. Two trough-like zones of later Devonian rocks have been reported in the upper and upper central portions of the watershed. Intrusion of more resistant igneous rock associated with these sediments has given rise to the rugged hills that are found on the Aroostook River in Maine and along the Green River.

Below Woodstock, Devonian intrusives are also reported and, here again, the topography is more rugged. Downstream from here, starting a few miles above Fredericton, weaker carboniferous shales and sandstones characterized by a reddish colour underlie this area of low relief. A band of more resistant rocks is found paralleling the coast above St. John. At least a part of these rocks is believed to be of Precambrian age.

While many minerals have been identified in the St. John basin, bituminous coal and limestone have so far had the largest production. More intensive prospecting however may uncover commercially important deposits of other minerals.

Beechwood Site

The St. John River is about 700 ft. wide as it makes its southerly course through the Beechwood site. From a water level at 180, the west bank rises steeply for some 125 ft. On the east bank, there is an abrupt rise of over 60 ft. to a terrace that continues more or less level for some 650 ft. where the main east wall of the valley begins. This wall rises steeply for some 50 ft. and then continues with a gentler rise to above elevation 500.

Surface Geology

Two distinct types of overburden, both of glacial origin, are found at Beechwood. At the higher elevations on the main slopes of the valley, bedrock is overlain by a thin deposit of silty till. At the lower elevation, the overburden was laid down as the ice retreated at the end of the last period of glaciation.

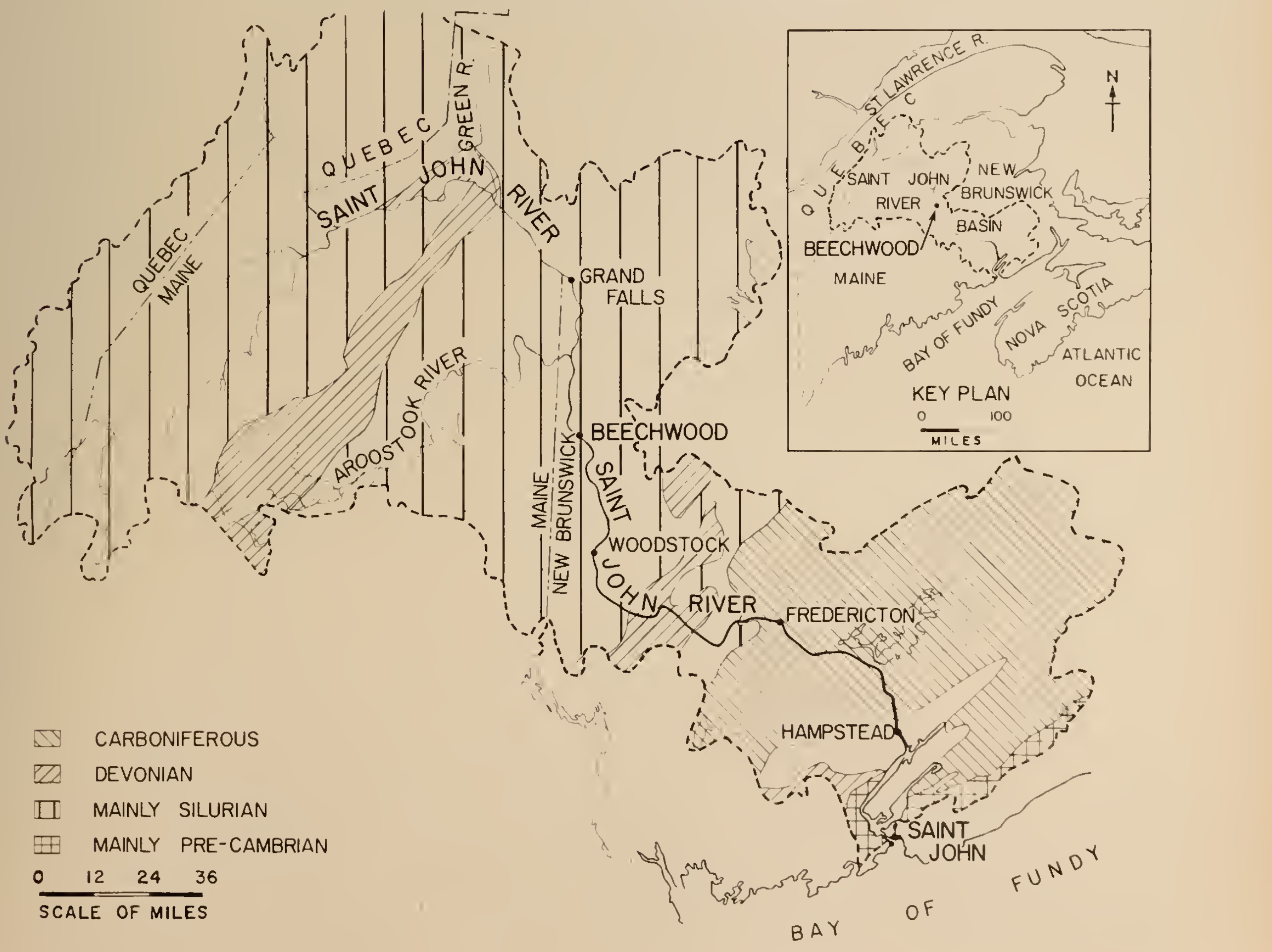
During the main period of glaciation, the whole of the land was covered by untold feet of ice. The ice ceased to advance and began to melt away. The highest part of the land became ice-free first. As the ice continued to melt the tops of the hills and ridges were exposed, while ice still remained in the valleys. A drainage pattern was set up between the valley walls and the ice, and under the ice itself. These streams flowing from the ice were charged with detritus which they deposited as Kame terraces along the valley walls. As further melting took place, the ice retreated gradually upstream and the Beechwood area was free of ice. The river flowing down the valley from this retreating ice dropped outwash deposits of sands and gravels on the valley floor. These outwash deposits were modified as the river channel changed due to varying flow, and more terraces were formed. After the final retreat of the ice from the watershed, the river proceeded to cut down through these deposits giving rise to the present overburden topography at Beechwood.

While not numerous, outcrop at Beechwood shows the bedrock to be an incipient slate or argillite. Cleavage, steeply dipping and frequently at right angles to the river, is well developed. Where identifiable, bedding is frequently contorted. This rock is brownish to dull grey on the weathered surfaces, and dark grey to jet black on the fresh cleavage faces. Although it is a dense rock it is not too resistant to frost action.

Site Investigation

Based on investigation in the late 1920's, the river profile and other considerations, the Beechwood area

Fig. 1 St. John River Basin — Generalized Geology



appeared to be one of the most favourable sites for power development on the St. John River. Starting in 1948, the New Brunswick authorities began subsurface investigation at Beechwood. At this time, 27 diamond drill holes were put down to establish the bedrock profile across the valley. These holes were drilled near the "K" line which eventually became the baseline for the structures. The holes were drilled 20 ft. into bedrock and an examination of the cores indicated that the rock had ample strength to support the proposed structures but that there were planes of seepage in the bedrock.

In 1950, holes 28 to 55 were drilled. This time holes were drilled both upstream and downstream of the "K" line to ascertain whether or not more favourable bedrock elevations could be obtained by moving several hundred feet in either direction.

In 1952, holes 56 to 67 were drilled and more detailed data were obtained.

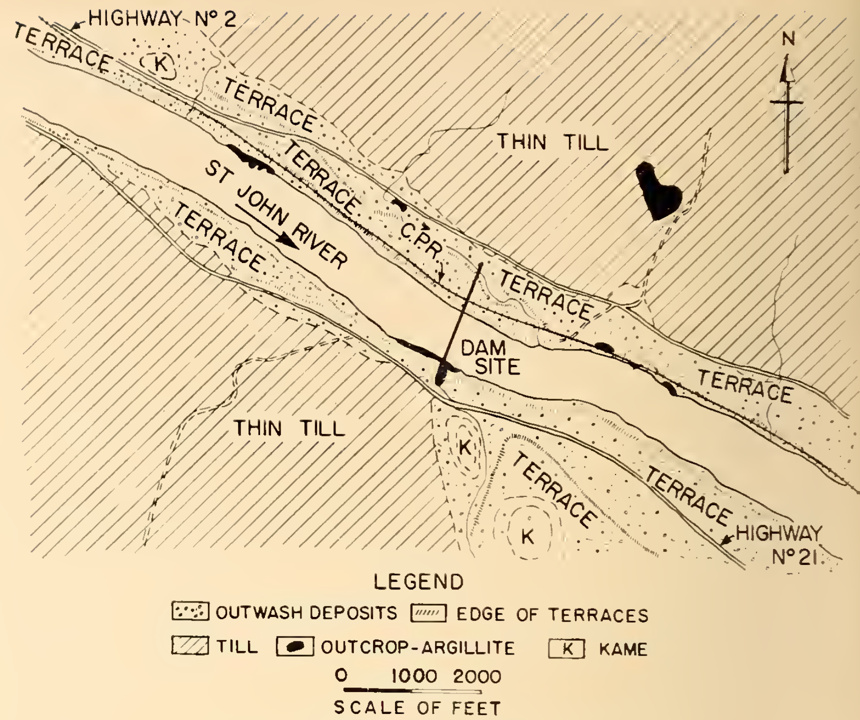


Fig. 2 Beechwood — Surface Geology

With the completion of this drilling, it was apparent that the "K" line represented the most favourable location for the proposed structures. The bouldery alluvium in the river bed varied in depth between 0 to 30 ft. and water testing of the holes put down in the east bank terrace showed this deposit of sandy gravel to be pervious down to bedrock. No evidence of solution along joints had been found in the argillite. Water testing in these shallow holes showed little loss of water except in the upper 10 ft. of the bedrock.

The staff of the Commission assembled detailed records covering the investigation and cores were logged by Dr. W. J. Wright and by Dr. G. S. MacKenzie. Overburden samples were subjected to laboratory tests by Associated Designers and Inspectors at Fredericton. This testing disclosed that, while the sands and gravels were well graded, they contained a sufficient percentage of unsound shaley particles to make their use as concrete aggregate questionable.

This then was the data available when the decision was taken to proceed with the development at Beechwood early in 1954. As the previous drilling had in general only penetrated 20 to 30 ft. into bedrock, it was decided to undertake a program of deeper drilling to prove up foundation conditions to depth. The new holes were drilled to depths of 100 ft. into bedrock with some holes to 150 ft.

Drilling from a barge in the St. John River in the summer and fall of 1954 was a hazardous occupation. During this period extremely heavy rain storms were all too frequent, and the river was in flood stage nearly every month. The water elevation would jump several feet in a matter of hours. Major fluctuations tended to occur on Saturday nights when no one was working and twice a diamond drill ended up on the bottom of the river when the barge broke its moorings and capsized. This drilling program of holes 68 to 94 was finally completed from the ice during the winter of 1954-55.

This drilling disclosed artesian zones in both the overburden and the bedrock. In the overburden, the artesian condition showed up in the drill holes put down along the east side of the tailrace. The indicated flow was small and the head was slightly above river level. In the bedrock, the artesian flows were found largely in the eastern half of the river channel. The maximum static head measured was some 25 ft. above river level. Along the "K" line, the maximum flow was recorded at hole 75 just west of the intake. This hole flowed at a rate of 144 gallons per hour, the measurement being made 4 ft. above river level. At hole 69, near the downstream east side of the tailrace excavations, similar measurements gave a flow of 330 gal. per hour. The artesian flows were encountered in bedrock at varied elevations and correlation of these water bearing zones from hole to hole proved impossible. This was probably due to the cleavage and joint planes being nearly vertical.

By March 1955, drill holes 1 to 94 had been completed in this investigation at Beechwood. Of a total of 7,232 ft. of hole put down, 2,912 ft. were through overburden and 4,320

Table I

Pattern of Curtain Grouting Parallel to Upstream Face of Structures

Location	*Number of Rows*	*Spacing Between Rows (in ft.)* (1)	*Average Hole Spacing (in ft.)* (1)
West end to Sluice Pier 6	3	9, 11	65, 17, 13
Sluice Pier 6 to Regulating Section	3	5, 6	5.5, 6, 10
Regulating Section	2	4	7.5, 7.5
Intake	4	5.5, 2.5, 3	12, 6, 12, 12
East Embankment	2	5	12, 6

(1) Figures on left refer to upstream row, succeeding figures refer to next row downstream, etc.

ft. were cored in bedrock. It was apparent that a very extensive grouting program would be required to prevent passage of water through the bedrock when the head was raised. If the seepage paths were not sealed off there would be a loss of water and possible development of uplift pressures under the structures. Also, there would be an extremely slow deterioration of the foundations due to the gradual removal of the minor zones of more soluble minerals that formed occasional incomplete fillings in the fracture and joint planes. The drilling indicated that there were more of these potential seepage paths extending from about the centre of the river to the east bank. It was also realized that blasting would cause the rock to open up and shatter along the closely spaced cleavage planes, and that care would be required during excavation to prevent excessive overbreak and damage to the foundation rock.

Table II

Drilling and Grouting Data

Location	*Number of Holes*	*Footage*	*Bags of Cement Injected*	*Bags per Foot*
Curtain Grouting				
Sluice Section				
West end to Pier 6	52	6,088	79	0.013
Pier 6 to Pier 10	95	14,088	583	0.04
Regulating Section	31	3,174	98	0.03
Intake and Earth Embankment	410	40,728	5,903	0.14
TOTAL	588	64,078	6,663	0.104
Blanket Grouting				
Sluice Section				
West End to Pier 6	69	992	49	0.05
Pier 6 to Pier 10	91	1,492	102	0.07
Regulating Section	27	431	4	0.01
Intake Powerhouse Tailrace areas Earth Embankment	2,108	40,968	3,837	0.1
TOTAL	2,295	43,883	3,992	0.09
TOTAL BLANKET AND CURTAIN	2,883	107,961	10,655	0.098

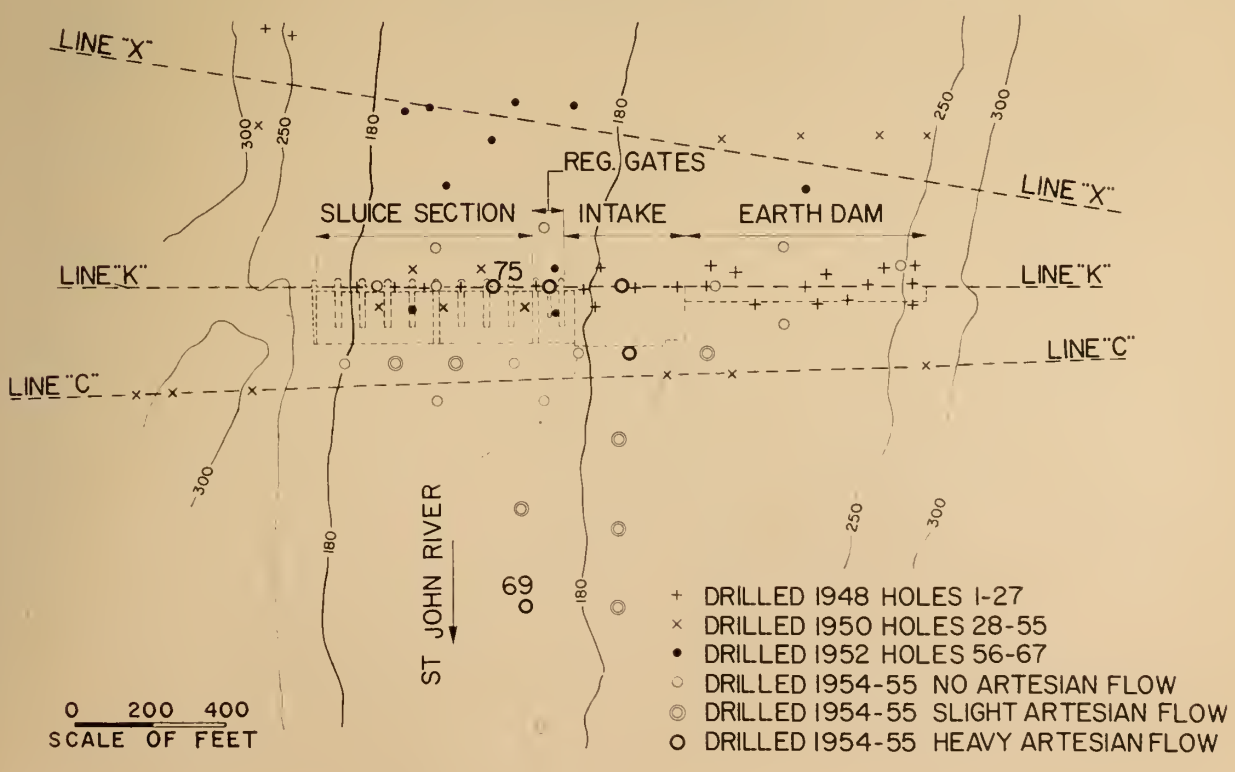
Construction Period

During the first year of construction when the westerly half of the river was dewatered, excavation, drilling, testing and grouting showed that foundation conditions were much as had been expected. As usual, the bedrock surface was found to depart slightly from the profile assumed from the drill hole intersections.

When the overburden was removed, the exposed bedrock surface was found to be massive and to be composed of tough, dense argillite. Considering the glacial and post-glacial history of the valley, it could be expected that any softer zones would have been eroded away. Minor irregularities in the surface were frequent due to differential erosion along slightly less resistant zones. As the work proceeded toward the east bank, more open joints or seams were found to depth in the bedrock. These zones proved amenable to grouting.

During the second season, excavation of the intake-powerhouse area got under way during the winter time. Excavation of overburden and rock soon disclosed a fault that

Fig. 3 Exploratory Drill Holes



crossed the baseline at pier 12 some 35 ft. west of the west end of the intake. This fault ran in an upstream-downstream direction and dipped 45° to the east.

This fault zone was narrow, generally a foot or less in width and consisted of angular fragments of brecciated argillite, unbrecciated calcite in stringers and pods up to 4 in. wide and minor fault gouge. The zone was sufficiently open to allow relatively free circulation of water and minor disintegration would result if the flow of water was to go unchecked. The unbrecciated condition of the calcite and the undisturbed till overlying the zone indicated that this fault was dormant. While five holes had been drilled in this area, none had intersected this fault zone.

The west wall of the draft tube excavation cuts this zone above grade. This left a wedge of rock lying on top of the fault zone unsupported on the east side. It was decided to remove this wedge of rock to the upstream limit of the draft tube excavation and replace it with concrete. Upstream from here to the baseline, the zone was drilled and grouted to refusal to a vertical depth of 175 ft.

The rock in the intake-powerhouse area shattered badly during excavation and opened up along the highly developed cleavage planes. The major direction of cleavage was across the river and dipped steeply downstream. The final boundary between draft tube and intake excavation coincided with this cleavage.

Other cleavages were also well developed and the excavated rock surface tended to break down into small plates standing nearly vertically. An intensive program of grouting was required to consolidate the upper 20 ft. of the rock in this area.

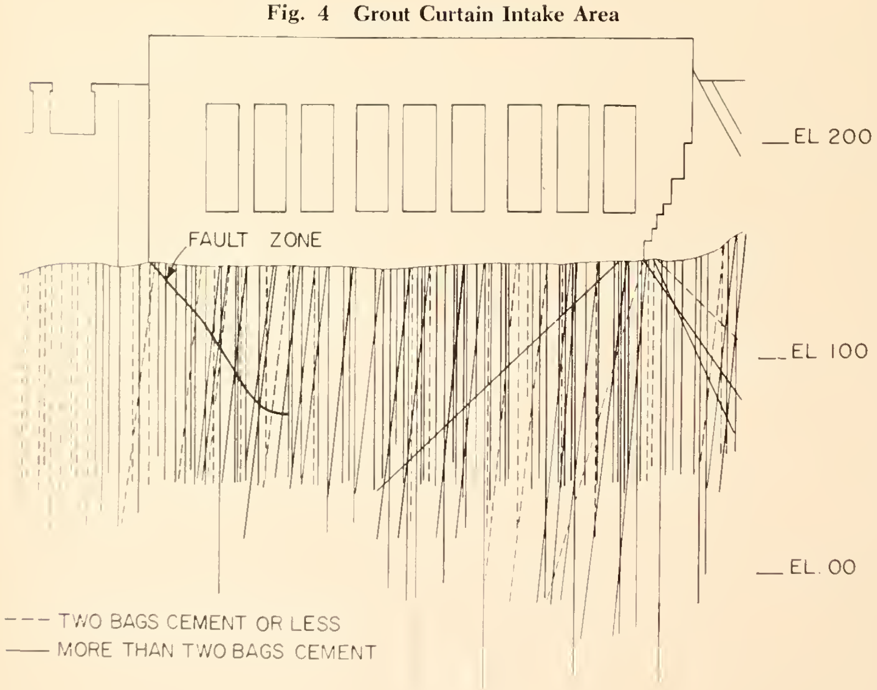
When overburden was removed from the east embankment area, the rock surface was found to be extremely irregular. In order to facilitate the placing of the rolled earth core, the surface of the bedrock was cleaned and gunited. Fill concrete was placed where required, to obtain a relatively smooth surface.

Construction Materials

Due to the shaley nature of the bedrock, it could not be used for concrete aggregates. Coarse aggregate was obtained from an outwash terrace deposit some three miles upstream from the site. The pit run gravel was crushed, the sand was removed, the gravel was washed and passed through a heavy media separation unit. Some 18% of the light weight particles were rejected in this process and the resultant gravel made a first class concrete aggregate. The fine aggregate was a natural sand brought in by rail from St. John Harbour.

As previously mentioned, the glacial till overlying bedrock is a very thin deposit in the Beechwood area. How thin these deposits were was soon learned when borrow pits were opened up for the core material for the east embankment. While the grading of the material was excellent, the thinness of the deposit, the irregular nature of the bedrock surface and the high moisture content made earth-fill construction difficult during wet weather. The terrace deposits provided excellent sand and gravel for the shell of this structure.

Fig. 4 Grout Curtain Intake Area



Grouting

Study of the drilling records, the cores, and the water testing and artesian data obtained during the exploratory work, indicated that, while many of the openings in the bedrock were very thin, they were relatively free of sand, clay and gouge. It was apparent that curtain grouting to seal off the water passages to depth and blanket grouting to seal and consolidate the near surface zone of the bedrock could be effectively carried out using only a cement-water grout without resorting to the use of clay or chemicals. It would be necessary to use a very dilute grout to ensure penetration and sealing of the thin seams and openings.

At the beginning of the grouting operations, a comparison was made between water test data and grout acceptance when the grout used consisted of one part of cement and six parts of water. This indicated that the grout would penetrate and seal the fine seams in the bedrock. Subsequently, this grout mix was used for the initial injection into any hole or section of a hole. Where this grout mix would not build up in and seal the larger openings encountered in the bedrock, the mix was gradually thickened, ratios of one cement to one water sometimes being reached before the pressure began to build up in the drill hole. The ratio of water to cement was then increased and the section of the hole was grouted to refusal with the one cement to six water mix.

Schedule

The grouting program was planned so that the time interval between completion of excavation and the placing of concrete in a section was the minimum necessary to effect the sealing and the consolidation of the bedrock foundations. In some sections, where the primary pattern of curtain grout holes had shown uniform and relatively tight foundation conditions, intermediate holes were drilled and grouted after the concrete was placed in order to expedite the overall progress of the work.

Blanket holes were drilled and grouted prior to concreting except in the intake area where a 3-ft. thick concrete slab was placed and in the east embankment area where the rock surfaces were gunited and a similar slab was placed over part of the area. In both of these sections, the blanket grouting was approximately 90% complete prior to this surface treatment.

In the western section of the river which was dewatered first, 7,080 ft. of curtain and blanket holes were drilled and 260 bags of cement were injected between August 10th and November 16th, 1955. In the central and eastern sections, 100,880 ft. of hole were drilled and 10,395 bags of cement injected between January 30th and August 31st, 1956.

Personnel

The owner provided on-site supervision of this program, assembled all drilling, testing and grouting data, and recorded this information on plans.

The owner's staff normally consisted of one general supervisor in charge of both shifts who also supervised the blanket drilling and grouting. On each shift there was a grouting supervisor, one inspector for each grout pump, and one inspector for each three diamond drills on curtain grouting.

During 1956, the personnel on site for drilling, testing and grouting consisted of one engineer, one clerk, shift foremen for drilling and for grouting, drillers, pump operators, helpers and labourers. In the water testing crews, two men were normally required to set the inserts at the required elevations in the holes and one man operated the pump.

For grouting, the crew consisted of a mixer operator, a pump operator, a labourer for handling cement and two men to adjust the inserts in the hole and operate the control valves at the header.

Equipment

Skid-mounted gasoline-powered diamond drills were used to drill the curtain holes. Pipe "A" frames on these machines speeded up rod pulling. Wherever the rock profile permitted, timber rails were set up to facilitate movement of the drills from hole to hole.

Hole size was AXT—1⅞ in. in diameter. Coring bits were used only when core was required for examination and study.

Four diamond drills, on a two shift basis, were in use at one time during 1956.

The 2-in. diameter blanket holes were drilled almost entirely by wagon drills. These machines were equipped for wet drilling so that the cuttings would be flushed to the surface and not become lodged in the crevices and seams in the rock. Jackhammers equipped for wet drilling were used in the few locations where intermediate holes less than 10 ft. deep were required. Ten wagon drills were in use at one time during 1956.

Small diamond-drill type gasoline-powered pumps were used for water testing and washing of holes. Single expanding type inserts were used for testing holes below any given elevation and double-type inserts for the sectional testing of holes. The latter type was made up to test 5-ft. lengths of hole. The capacity of these pumps was about 750 gal. per hour.

Water meters were used to measure the amount of water injected into a hole. Rubber hose 1 in. in diameter was used for delivery lines.

During 1955, when the western section was grouted, the grout mixing was done at a central location and pumped to the holes. This equipment consisted of a horizontal paddle-type mixer, a double-tank paddle-type agitator and a duplex-slush pump: the flow from mixer to agitator to pump was by gravity. During the second year, a grouting unit consisted of a similar double-tank agitator where the grout was mixed and agitated, and the slush pump, both mounted on a moveable double-deck platform. The grout flowed by gravity from the agitator to the pump. With this moveable set-up, the distance from the pump to the hole being injected was kept under 100 ft.

All this equipment was air powered. The pumps used were the long stroke type and were equipped on the grout end with rubber pistons, rubber-faced valves and removable hardened valve seats and cylinder liners. Dismantling of the grout end for cleaning could be carried out easily and quickly. These pumps were rated at 120 gal. of grout per minute. During 1956, as many as four pumps and three agitators were in use at one time.

Meters were used to measure the amount of water batched and the cement was measured by the bag. A bag was assumed to be 1 cu. ft. for batching purposes. The grout was screened between the agitator and the pump to remove any foreign material.

The hose line from the pump to the hole was 1½ in. in diameter and the return line from the hole to the agitator was one inch hose. An accurate pressure gauge, protected from contact with the grout, was installed on the grout header at the hole. Immediately beyond the header, a stop cock was installed on the return line so that the effective pressure on the hole could be controlled within narrow limits by varying the amount of grout recirculated. With this arrangement, it was possible to maintain high velocities in the pump and hoses thereby preventing blockages due to sedimentation even though a hole was accepting grout at a low rate.

Several types of expanding hole inserts or expansion plugs were used to secure a seal between the wall of the hole and the injection pipe. With rock conditions at Beechwood, the

Table III

Drill Production Data May–August 1956

	Average Footage Per Hour
Curtain—Diamond Drills	4.4
Blanket (2 stage)—Percussion Drills	2.2

Table IV

Drilling, Testing and Grouting Cost Data

Item	*Quantity*	*Cost per Foot*	*Cost per bag of Cement*	*Cost*
Curtain Drilling	64,078 ft.	$3.10		$199,224.00
Blanket Drilling	43,883 ft.	2.80		124,053.00
All Drilling	107,961 ft.	3.00		323,277.00
Testing and Grouting	107,961 ft.	.67		72,456.00
	10,655 bags		6.80	
Total Cost of Drilling, Testing and Grouting exclusive of Supervision, etc.				$395,733.00

double pipe assembly with a soft rubber expansion section proved to be the most effective type of insert.

The grout pumps, grout agitators and wagon drills were operated by compressed air. All the air available from the main job supply was used and in addition, during the peak period, portable compressors with a total rating of over 1,100 cu. ft. per minute were required.

The various types of equipment required the following amounts of compressed air:

Wagon Drill	320 cfm
Jackhammer	75 cfm
Grout Mixer	85 cfm
Grout Agitator	85 cfm
Grout Pump	85 cfm

Fig. 5 Fault Zone — West End of Intake

Curtain Grouting Pattern

The grout curtain parallel to the upstream face of the structures consisted of two or more rows of holes. Under the concrete structures, these rows of holes were near the upstream face, in all cases being at least 20 ft. upstream from the rock drains. In the earth embankment, the rows were drilled under the upstream one-third of the core. The distance between the two outside rows varied between 4 and 11 ft. under the different structures. The holes were drilled to depths of 100 to 150 ft.

The position of the holes in the rows was staggered relative to the position of the holes in adjacent rows. The first holes were usually drilled and grouted on 25-ft. centres and additional holes were then drilled and grouted on diminishing centres until the section was grouted up.

When a hole accepted two bags of cement or more distributed throughout the length of the hole or one-half bag or more of cement in any one 10-ft. section of the hole, additional holes were required. These holes were put down on both sides of the hole in question, midway between this hole and the two adjacent holes in the row. This process was repeated as required and, if necessary, additional rows of holes were drilled and grouted until acceptance of grout was less than that specified above.

In the sluice and regulating section all holes were vertical. In the intake and earth fill section, vertical and inclined holes were put down. The inclined holes were sloped to the west at 6° off vertical and upstream to coincide with the upstream line of holes at the maximum depth reached.

At the east end of the intake and powerhouse, drilling and testing indicated that the bedrock was relatively open and artesian conditions existed. A grout curtain beginning at the curtain parallel to the upstream face was extended downstream under the east intake-powerhouse retaining wall for 150 ft. Two rows of vertical holes, 5 ft. apart, were put down to depths of 100 to 150 ft. Between these rows, holes dipping at 60° downstream were drilled and grouted. The holes in rows were spaced twelve feet apart and staggered relative to the holes in adjacent rows.

Fig. 6 Bedrock Cleavage during excavation

Procedure

The drilling of curtain holes usually proceeded to the desired depths with little difficulty. When caving of the walls of the holes or relatively heavy artesian flows were encountered, drilling was stopped, tests were made, and the zones were grouted before drilling continued.

Records were kept during drilling to show artesian zones, changes in colour or volume of return water and the driller's comments on the nature of the rock. Any other information which could be of value for the proper grouting of the hole or for the layout of additional holes was recorded.

The use of grease on the drill rods was prohibited because of the danger of blocking the finer seams.

Due to the volume of water used during drilling, diamond drill holes are relatively free of sludge and normally do not require cleaning prior to grouting. In those holes where the insert could not be lowered to the required depth, a small diameter hose was run down into the hole and the obstruction was flushed out using alternate applications of compressed air and water.

Water testing of the drill holes located the open seams in the bedrock. As the grouting progressed, water testing also gave a measure of the effectiveness of the work already carried out.

In the western section where each hole was drilled to its total depth prior to testing and grouting, the first water test was normally made at a depth of 30 ft. When the leakage in a hole below this depth was less than 60 gal. per hour, the hole was then grouted. When the leakage was greater than this amount, the hole was water-tested throughout its full depth in 5-ft. intervals. A sectionalizing insert assembly was used to locate all the open seams.

In the central and eastern sections, the sectionalizing insert was used for practically all the testing.

Where seams provided interconnection between two or more holes, inserts were placed in the holes and water was pumped down one hole and then the other to flush out the seams. This pumping was continued until the effluent was clear. Dye was added where necessary to prove interconnection between holes.

Both the step method and stage method of grouting were used. In the step method, the hole was drilled to its total depth, tested and then grouted in steps from the bottom to the top. The insert was set ten feet from the bottom of the hole and this section of the hole was grouted to refusal. The procedure was repeated in 10-ft. steps. At the top of the hole, a short length of pipe was cemented into the hole and the final injection was made through a plug valve on this pipe. The valve was closed and the grout was allowed to set up under pressure.

Fig. 7 Near Vertical Rock Face on Completion of Excavation

If the hole accepted more than the two bags of cement, it was washed out 8 to 12 hours later and regrouted.

Where interconnection existed between holes, the holes were grouted up to the level of interconnection and then inserts were placed in the holes above this elevation. Grout was pumped down one hole and allowed to flow out the pipe in the other hole. By restricting this discharge, it was frequently possible to grout up the seams. Where this was not the case, the inserts were raised to the surface and grouting was carried out at reduced pressure; the grout was allowed to set up and the holes were washed out and regrouted. This procedure was repeated to refusal in each of the interconnected holes.

Pressures used were 15 p.s.i. at the surface plus 1 p.s.i. per foot of depth to the point of injection.

The stage method was adopted in the intake and earth embankment areas due to difficulties in sealing the inserts in the holes. The more highly developed near-vertical cleavage in this area was the cause of this difficulty.

With this method, the hole was drilled to 15 ft. and then grouted. Due to surface leakage only low pressures were used in this stage. After 8 to 12 hours, the hole was washed and later deepened 10 ft. This 25 ft. of hole was water tested.

If the leakage was less than 10 gal. per hour the hole was deepened another 10 ft. If the leakage exceeded 10 gal. per hour, the hole was grouted from the surface at a pressure of 50 p.s.i. This procedure was repeated to depths of 85 to 100 ft. dependent on the condition encountered, after which the hole was drilled to its full depth and then grouted in 10 to 20-ft. steps from

Fig. 8 Drilling for Blanket in Intake

the bottom to the surface. Pressures on this final grouting were 1 p.s.i. per foot of depth reducing to 50 p.s.i. at the surface.

Blanket Grouting Pattern

In the western section which was grouted during the first year, the primary blanket holes were laid out on 20-ft. centres throughout the base area of the structures. These holes were drilled vertically 15 to 20 ft. deep and were grouted in one stage. Holes midway between the primary holes were put down in all sections where appreciable quantities of grout were accepted or where the rock surface was seamy or broken.

In the regulating section, the primary pattern consisted of vertical 15 to 20-ft. holes on a 15 by 20-ft. pattern. Here again additional holes were put down between the primary holes, as required to consolidate and seal the surfaces.

Due to the open or shattered nature of the rock surface under the core of the earth embankment, in the intake-powerhouse area and in the tailrace channel extending 100 ft. downstream from the powerhouse, a much closer pattern of blanket grout holes was required.

Due to the nearly vertical cleavage, holes in alternate rows were inclined at 60° to the south and at 60° to the north. This primary pattern was on 10-ft. centres. Additional rows of holes with the holes in alternate rows inclined at 60° to the west and at 60° to the east were drilled midway between the primary holes. These holes were drilled and grouted to an average depth of nearly 20 ft. in two 10-ft. stages.

The rock wall between the powerhouse and intake excavation was drilled and grouted using horizontal holes. Here the pattern was variable.

Procedure

The blanket holes were not water tested. The holes in the western or sluice section and the regulating section were flushed out using air and water alternatively to remove all cuttings and sludge. They were then grouted to refusal from the surface and the grout allowed to set up under pressure.

In the intake-powerhouse area and under the earth embankment, the holes were drilled to a 10-ft. depth, flushed out and then grouted from the surface. Grouting was discontinued on the primary holes when further pumping would not increase the radius of grout leakage at the surface. Frequently, a grout mix consisting of one part of cement to six parts of water was injected for five minutes, followed by a grout consisting of equal parts of cement and water for a 10 minute injection period.

The partially hardened grout was flushed from the holes after 8 hours. Subsequently, the holes were deepened for the second stage, flushed out and grouted from the surface. The maximum pressure used during this second stage was limited to 50 p.s.i. Where the volume of grout acceptance warranted it, the hole was again flushed free of grout and regrouted.

During the first stage of grouting of the holes in the primary pattern, grout often came to the surface within a radius of 3 to 4 ft. from the hole. During grouting of the lower stage, this radius increased to 6 or 7 ft. Grout was observed coming to the surface as much as 12 ft. away. When the intermediate holes were grouted, relatively little grout came to the surface and usually within a couple of feet from the hole. In any sections where grout acceptance or travel indicated incomplete filling of the openings in the bedrock, additional holes were put down and grouted.

Results of the Grouting Program

During the drilling of some of the secondary holes into the fault zone lying in the westerly section of the intake, grout was recovered in the cores. This grout had penetrated and stabilized the loose material in the zone to such an extent that it could be cored for the first time. Examination of these cores and subsequent testing and grouting indicated that this grout had effectively sealed the zone.

In the sluice section, a sump collects the drainage from the contraction joints in the structures, from the rock drainage system under the structures and from the observation wells drilled into rock every 5 ft. along the inspection tunnel. In October 1958, over a year after the head was raised, the inflow into the sump was less than two gallons per minute. This is a very small inflow when one considers that these rock drains alone are draining an area in excess of 60,000 sq. ft.

It would seem therefore that the program of blanket and curtain grouting at the Beechwood Development has been effective.

HIGHWAY RESEARCH ACTIVITIES IN CANADA

(Continued from page 47)

improve interregional communication, while city planning and development has been neglected. Urbanization of the population has thus been promoted while the problems it causes have been forgotten. The highway can destroy the heart of a city which, in turn, can move out to destroy that highway. Such a development serves no useful purpose. It dislocates business and industry, disrupts the population and destroys the benefits of urban living. To avoid such consequences, planning techniques must be improved by research into the economic impact and social consequences of road and street improvements.

Conclusions

A logical pattern for road and street research in Canada has been established. The results of the first research survey of the Canadian Good Roads Association are most encouraging. They show that tremendous progress has been made in such work in the past few years, but also indicate that a much greater effort is needed.

The monetary benefits of road research are known. The need for doing such research in Canada, by Canadian engineers, is evident. Our highway departments, universities and industries have competent personnel to undertake such research. They require only the time, money and encouragement to get on with the job. It is only logical to provide the needed support for this work. The dividends will be great.

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THE ECONOMICS OF BY-PRODUCT POWER GENERATION

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

Any process for the conversion of heat into electrical energy involves the absorption of heat at a high temperature and the rejection of a large part of this heat at a lower temperature. Where the heat rejected can be used in some other process the over-all economy of the power generating cycle is very much improved. Power produced in such a manner is often referred to as by-product power.

Several processes have been used for the production of by-product power. The most common of these employs steam turbines of the back pressure or extraction type. This type of equipment has wide application and is considered here in some detail. An attempt is made to show what factors affect the over-all economy of such a cycle and what circumstances are likely to favour this type of installation. The effects of initial steam conditions, fuel costs, equipment costs, and load characteristics, both electrical and steam, are considered. These factors are illustrated by a typical example.

The application of by-product power generation to various industries is discussed, and descriptions of plants for the pulp and paper and chemical industries are given.

Although less widely applicable than steam turbines, gas turbines can also be used in a by-product power cycle. This is briefly discussed. Other refinements and alternative cycles are mentioned.

Indications are that Canada will, in future, become more and more dependent on thermal power production. While it is unlikely that any very large part of the country's needs will ever be met by the types of installation described, it is nevertheless important that due consideration be given any possibilities that do exist for the more economic use of our fuel supplies.

THE PRODUCTION of electric power by thermal means involves the conversion of heat into mechnical energy, a conversion subject to the basic limitations of the laws of thermodynamics. The process by which the conversion is effected involves the intake of heat at a high temperature and the discharge of heat at a lower temperature. Only part of the heat taken in can, even theoretically, be transformed into mechnical work. This part, given by the Carnot cycle efficiency, is equal to the ratio of the temperature drop to the absolute inlet temperature.

The Carnot cycle efficiency is, of course, an unattainable ideal and actual processes for the generation of power can achieve only a fraction of this efficiency. Losses are of many kinds, some due to the fact that the actual cycle falls short of the ideal cycle, others due to the mechanical losses and imperfections of the equipment used in the application of the cycle. Typical efficiencies realized in plants of different types are given in Table I.

The term "efficiency" as applied to the theoretical performance of thermal cycles is perhaps somewhat misleading since it implies that the heat rejected by the cycle constitutes a loss and it seems to suggest that this loss could, in a perfect cycle, be completely eliminated. A cycle which rejects no heat is, of course, theoretically impossible. However, cycles in which the heat rejected is not wasted but serves a useful purpose are quite common. It is with this type of cycle that this paper is concerned.

The uses for heat energy are numerous. They include all heating, cooking, evaporation and distillation processes, and occur in such industries as the manufacture of pulp and paper, the refining of petroleum, the distilling of alchohol, and the refining of sugar. Each such manufacturing process offers some opportunity for generating power without wasting heat.

The term "by-product power" has been used quite commonly in referring to power produced by this type of cycle and seems appropriate since power is not the main product but a by-product of the generation of heat for other purposes.

A number of cycle arrangements are possible, each of which may prove economical under certain circumstances. The factors which determine the economy of the process are numerous and not always easy to evaluate. It is essential therefore that a detailed study be made of the circumstances surrounding any particular application before a decision is made. However, there are some general principles involved and certain trends that can be distinguished. A discussion of these may be helpful in indicating in a general way what circumstances favour the generation of by-product power and when a detailed investigation should be undertaken.

Steam Turbines

The most common cycle used for the generation of by-product power involves the use of the steam turbine. In most processes that require heat, steam at moderate pressure and temperature is used as the heat-conveying medium; by generating steam at a higher pressure and passing it through a turbine before delivering it to the process a certain amount of by-product power can be produced.

In studying the economy of such a cycle the steam conditions at turbine inlet and exhaust assume a critical importance. Conditions at the exhaust are usually fixed by the temperature requirements of the particular process and cannot be varied to improve power production. However, inlet steam conditions can and should be selected to give optimum economy.

The simplest cycle for the generation of by-product power is shown in Fig. 1 and involves the use of a back-pressure turbine. This is suitable for the simpler applications where process steam is used at only one pressure and where either a reasonably close correspondence between steam and power requirements exists or there is supplementary power available at reasonable cost. In more complicated circumstances the turbine may be provided with controlled extraction openings to supply steam at other than exhaust pressure, or with a low pressure section and condenser to permit generation of some power independently of process steam requirements. Frequently also uncontrolled extraction openings for feedwater heating can be justified on the basis of the additional output obtained thereby.

For simplicity the discussion to follow will be based on the simple cycle shown in Fig. 1. However, the conclusions are valid in a general way for the more complicated cycles.

The power obtainable from a cycle such as that shown in Fig. 1 depends not only on the initial and exhaust steam conditions but also on the turbine efficiency. This in turn is largely a function of the steam flow through the unit, higher efficiencies being attainable in large units than in small units. The useful output is reduced not only by the losses within the machine but also by the increase in auxiliary power requirements over those for a simple process steam plant. The most important item of auxiliary power is that required to pump the feedwater to the higher pressure. In addition there is some increase in the power absorbed by the boiler auxiliaries as well as a small amount for other purposes.

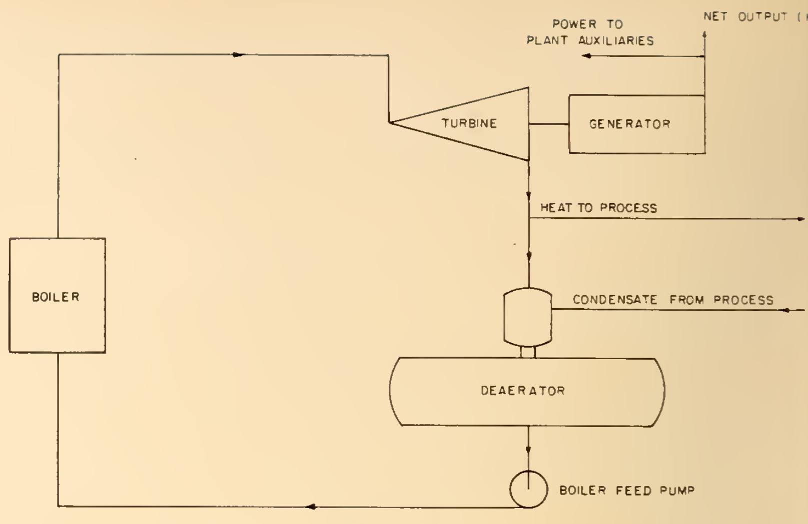


Fig. 1 Typical Back-Pressure Turbine Cycle.

Fig. 2 shows the approximate outputs available for various inlet and exhaust conditions. Although outputs are given in kwh. per million B.t.u. delivered to the process, turbine efficiencies are based on a constant demand of 150 million B.t.u. per hour and the figures are strictly correct only for a plant of this size. Because of the better turbine efficiency larger plants would produce somewhat greater outputs.

To estimate the total cost of by-product power it is necessary to consider each item of cost separately and to estimate, for each, both the cost of producing process steam only and the cost of producing steam and power. The difference then is the cost which must be charged to power generation.

The main items making up the cost of energy are:

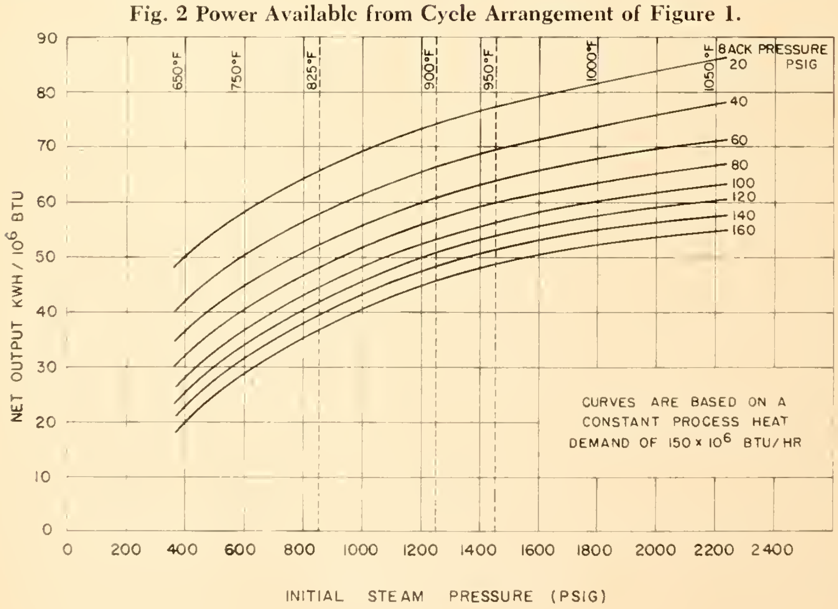
(1) Fuel
(2) Operation
(3) Maintenance
(4) Fixed charges.

Since the fuel charged to the generation of power is only that corresponding to the heat actually converted into power, fuel costs for by-product power are much lower than for power generated by other thermal cycles. The only losses to be considered are the mechanical and electrical losses in the turbine-generator and auxiliary equipment, the boiler losses and the heat equivalent of the additional auxiliary power. The total of these will usually lie between 20 and 25%, corresponding to efficiencies of 75 to 80% and heat rates of 4250 to 4550 B.t.u. per kwh. These may be compared with the efficiencies and heat rates for conventional cycles given in Table I.

Actual fuel costs vary widely throughout Canada from perhaps 15 cents per million B.t.u. for natural gas in some parts of Western Canada to more than 50 cents per million B.t.u. for coal in some areas of the Maritimes and Northern Ontario. The total range of fuel costs for by-product energy is therefore from about .6 mills to about 2.3 mills per kwh.

Operating costs must be estimated for the particular installation. Often it is feasible to operate a combined steam and by-product power plant with no more staff than would be required for a steam plant only. However, in the more usual case at least one additional man per shift will be required.

Fig. 2 Power Available from Cycle Arrangement of Figure 1.



Maintenance costs are variable ınd difficult to estimate. Usually it s satisfactory to assume that the ınnual cost will average 1½ to 2% of the capital cost chargeable to power generation.

Of the various items of cost listed hat of fixed charges, which is of ourse related to capital cost, is by ar the most significant. The capital ost chargeable to power generation onsists of the cost of the turbine-generator with its building, founda-ion, and auxiliaries, the increment n boiler cost due to the increase n pressure, the much smaller in-rement in boiler cost due to the ncreased output, and increments in he costs of feed pumps, piping and ther auxiliaries due to the increases n both pressure and capacity.

To illustrate the general trend, estimates of capital cost have been made for installations operating under the conditions assumed for Fig. 2. Here also a heat output to the pro-cess of 150 million B.t.u. per hour has been assumed. These estimates are shown in Fig. 3. Fig. 4 shows, for one value of back pressure only, the breakdown of these costs into the three major components.

In plotting the curves of Fig. 3 and 4 it has been assumed that the useful gross turbine capacity is that corresponding to the rated output of the boiler. This is an ideal condition that is seldom realized. In most cases there will be fluctuations in steam demand and these will operate to reduce appreciably the firm electrical output of the plant. Actual capital cost per kw. can therefore be expected to be generally higher than those shown.

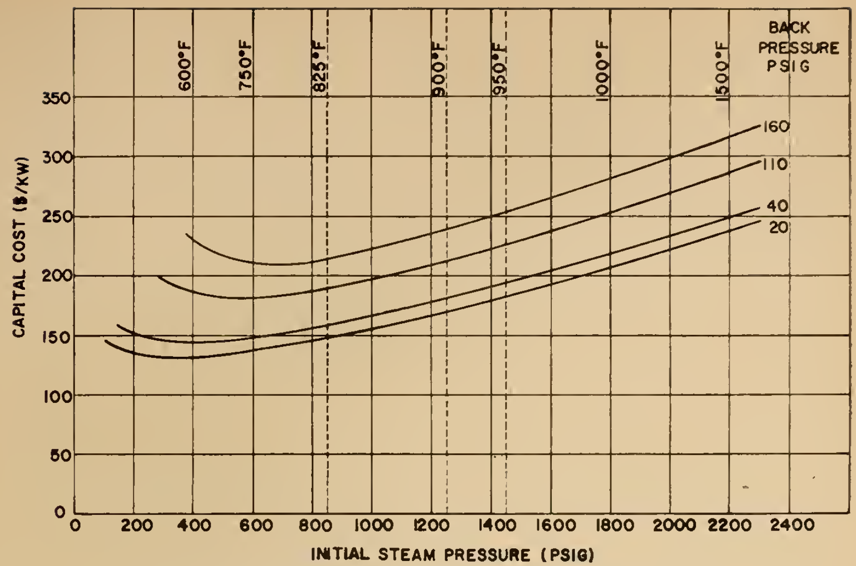


Fig. 3 Capital Cost of Equipment for Cycle of Figure 1.

It will be noted that, even under the favourable conditions assumed the capital costs for by-product power installations are not particularly low. They range from a minimum of about $130 per kw. to a maximum of over $330 per kw. For condensing turbine plants in the same range of sizes equivalent costs would be perhaps $200 to $250.

Two points in connection with Fig. 3 worth noting:

(1) The cost per kilowatt becomes lower as the back pressure decreases. This is a somewhat obvious result and is due primarily to the fact that low back pressures produce greater outputs for the same steam flow;

(2) For each back pressure there is an initial pressure which results in minimum capital cost per kilowatt. This optimum initial pressure increases with increasing back pressure, ranging from about 300 p.s.i. for a back pressure of 20 p.s.i. to about 700 p.s.i. for a back pressure of 160 p.s.i.

The second point deserves further comment. Since the fixed charges on capital investment represent the largest single item of cost, and since the total of the other items does not vary greatly with initial pressure, it is to be expected that the total cost of energy will show the same variation with initial pressure as does capital cost. This might at first glance seem to indicate that moderate initial pressures are invariably more economical than very high pressures. This is not necessarily true. In any actual installation the point of best over-all economy is the point of minimum total costs rather than the point of minimum cost per kwh. This occurs at the point where it becomes cheaper to turn to some other source of power rather than to increase the output of steam power by raising the initial pressure. At this point the incremental rate for by-product energy will equal the incremental cost of energy from another source In many cases where power costs are high this point will correspond to an initial steam pressure much higher than the point of minimum cost shown on the curve.

It should be noted further that the data in Fig. 3 are for relatively small plants and that for larger installations the optimum pressures will be somewhat higher.

While the data of Figs. 2 and 3 are felt to be reasonably accurate for the conditions assumed and while

Fig. 4 Breakdown of Capital Cost.

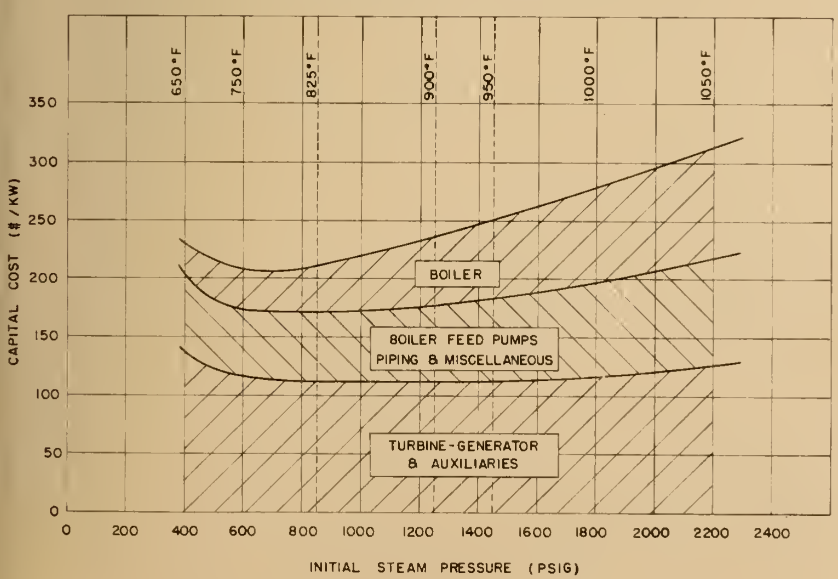


Table I—Typical Over-all Efficiencies of Power Generation

	Plant Heat Rate Btu/k.w.h.	Over-all Efficiency %
Steam Turbines		
33 Mw., 600 p.s.i.g., 825°F	13,700	25
50 Mw., 1450 p.s.i.g., 1000°F	10,200	33
300 Mw., 2400 p.s.i.g., 1000°F/1000°F	8,900	38
325 Mw., 5000 p.s.i.g., 1200°F/1050°F/1050°F	8,106	43
Gas Turbines		
2 Mw., (Simple cycle)	21,000	16
30 Mw., (Cycle with reheat and intercooling)	14,000	24
Diesel Engine		
2 Mw., (Turbo charged)	9,760	35

they show what are believed to be real trends in the performance and cost of back-pressure turbine installations they do not provide answers applicable to any actual set of conditions. A proper evaluation of by-product power generation in any given case is a very complex and tedious undertaking. Some of the complications that must be taken into account are the following:

(1) There are usually fluctuations in steam and power demand. The effect of variations in steam demand has already been mentioned. Variations in power demand have a similar effect. Furthermore there may or may not be coincidence of steam and power demands. In some cases it may be necessary to provide full electrical output at times of minimum or even zero steam demand, and in these cases consideration must be given to supplementary sources of power. In some instances purchased power may be economical. In others a low pressure section of the turbine together with a condenser may be justified, despite the large increase in capital cost and in fuel consumption. There are even occasions when it is more economical to waste exhaust steam to the atmosphere during these periods than to incur the additional costs to provide increased output in other ways;

(2) The need for spare boiler or turbine capacity must be considered. If either or both of these is provided it will of course add substantially to the cost. The question is primarily one regarding the consequences to the industry served of interruptions in either steam or power supply and no useful generalizations can be made. It might be mentioned however that, in the authors' experience, the present trend seems to be in the direction of eliminating spare capacity and accepting the risk of service interruptions rather than to make the very considerable capital investment required to ensure continuous service;

(3) The possibility of interconnection with a utility may have to be considered. In some cases this may result in more complete utilization of the available output. In others, where several plants separted by appreciable distances are involved, it may be possible to use the utility's transmission system to transfer output from one plant to another, thereby reducing the need for spare capacity or minimizing the effects of equipment outages.

It may be of interest to outline the results of a specific study. In the case selected consideration was being given to the rebuilding of a plant for the supply of process steam, and it was felt necessary to consider generation of by-product power at the same time.

Table II presents only the results of the study for back-pressure turbines, although the use of extraction machines was also investigated. It will be noted from this table that the installation cost for this particular by-product power plant is considerably higher than indicated by the corresponding points on Fig. 3. This difference may be attributed to the following conditions:

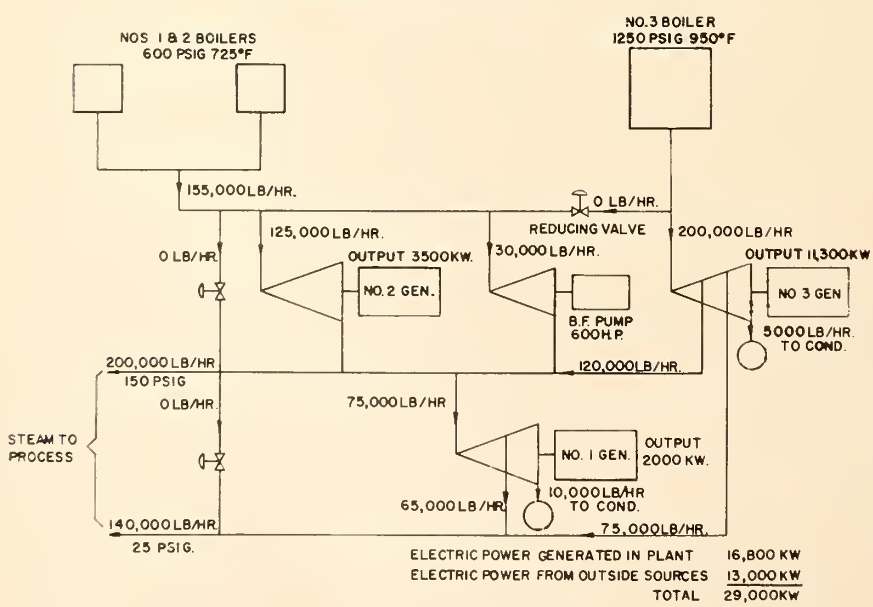
(1) The study was based on the use of turbine-generators of standard ratings;

(2) It was necessary to provide excess capacity in the boiler and auxiliaries. The steam demand showed considerable hourly and daily variation in addition to a seasonal variation due to building heating, the demand for 40 p.s.i.g. steam ranging from 116,000 to 185,000 lb. per hour. Moreover there was a demand for 125 p.s.i.g. steam which varied from 47,000 to 64,000 lb. per hour. The power requirements for this process were large and nearly constant but the nature of the contract for outside power did not permit interchange of energy between the plant and the utility and only small fluctuations in demand for this outside power were permitted under the terms of the contract. By-product power could, therefore, only be generated from the minimum steam flow of 116,000 lb. per hour, but some additional firm power was obtained from the steam required to heat the condensate returning from the 125 p.s.i.g. system.

Examples of Steam Turbine Installations

The pulp and paper industry, which in terms of total value of product is Canada's largest, provides perhaps the most frequent examples of back pressure and extraction steam turbine installations. Here the power demand is generally constant while the steam demand is subject to considerable variations. By-product power is never sufficient to meet the

Fig. 5 Typical Power Plant Cycle — Paper Mill.



total needs and usually supplements power from other sources. Often paper mills are located where fuel costs are high and new sources of power expensive. The incentive to investigate by-product power as a means of meeting increased demand is therefore considerable.

A typical paper mill steam plant designed for by-product power generation is shown diagramatically in Fig. 5. This diagram illustrates clearly the development that has taken place as power demands have increased and it has become necessary to find additional sources of power. It will be noted that for the most recent installation an initial pressure of 1250 p.s.i. has been selected. This high presure may be attributed to the relatively high cost of alternative sources of power.

In the authors' experience all of the by-product power installations supplying paper mills are owned by the paper companies themselves. Investigations have occasionally been made of the feasibility of supplying both steam and power from a plant owned by a public utility but no actual cases of this are known. Presumably the fact that the paper mill is invariably able to absorb all of the power obtainable is a determining factor.

Nevertheless there undoubtedly would be advantages in supplying process steam and power from a plant whose operation could be closely integrated with that of a utility. For one thing a more complete utilization of the available energy could be effected. Secondly the problem of spare capacity could be more efficiently dealt with since a pooling of reserves between the industry and the utility would be possible. Finally an alternative source of power would automatically be available to the industry to take care of periods when the production of by-product power was at a minimum because of reduced steam flow.

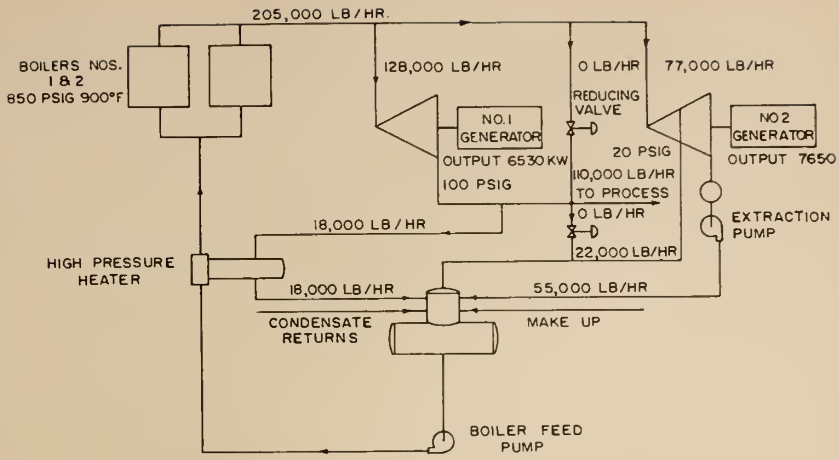


Fig. 6 Typical Power Plant Cycle — Chemical Process Plant.

Undoubtedly the most attractive type of installation for such a combined plant would consist of automatic extraction turbines having a condensing section of sufficient capacity to permit full output under all normal conditions.

A diagram for an isolated chemical plant that is self-sufficient insofar as steam and power requirements are concerned is given in Fig. 6. In this case one turbine-generator is equipped with a low pressure section and condenser to permit generation of sufficient power to supply the plant's needs with minimum process steam demand. Normally there is sufficient by-product power to take care of all requirements and the condensing unit is either shut down or operates with cooling steam only passing through the low pressure section to the condenser.

Oil refineries offer interesting possibilities for the generation of by-product power. The steam demand, for large refineries at least, is usually more than sufficient to permit generation of all of the power needed. The result has been that in some cases in the United States the supply of both steam and power has been entrusted to a public utility. Examples which have been described in the literature are the Linden plant of the Public Service Electric and Gas Company[1], and the Avon (California) steam plant of the Pacific Gas and Electric Company[2]. In both cases large quantities of process steam are delivered to the refineries from extraction turbines and fuel is obtained from the refineries in exchange.

Although no similar plants are known in Canada it would seem that, with Canada's growing oil industry, plants of this type may require consideration in future.

Gas Turbines

While the steam turbine is more widely used for by-product power generation than other prime movers, it is by no means the only type of equipment suitable. The gas turbine in particular offers interesting possibilities, despite its serious limitations. The limitations have to do chiefly with the restricted range of fuels that are suitable and the high excess air which must be used to keep the turbine inlet temperature within the limits of available materials. Of these the first is by far the more important since it rules out completely the use of solid fuels. The second serves chiefly to limit the output available.

Because of the high excess air quantities, the use of the gas turbine for generating by-product power presents a somewhat different problem from that of the steam turbine. It is possible, of course, simply to exhaust the gases from the turbine to a waste heat boiler which uses the heat to produce process steam. However, flue gas losses in this case are abnormally high and the whole process falls far short of the efficiency that can be realized in a steam turbine plant. Steam in this case becomes a by-product of power generation. To avoid the high losses it is neces-

Table II—Results of Typical Study for By-Product Power Generation

Turbine inlet conditions..°	600 p.s.i.g./750°F	850 p.s.i.g./825°F	1250 p.s.i.g./900°F
Turbine back pressure...	40 p.s.i.g.	40 p.s.i.g.	40 p.s.i.g.
Heat to process.........	124 x 10^6B.t.u./hr	124 x 10^6B.t.u./hr	124 x 10^6B.t.u./hr
Net power output.......	6900 kw.	7950 kw.	9000 kw.
Capital cost:			
For this installation—$/kw.	174	216	248
From fig. 3—$/kw.........	148	158	182
Cost of energy:			
Fixed charges—10%......	0.23 c/kwh.	0.29 c/kwh.	0.33 c/kwh.
Fuel cost .. $0.45/$10^6$B.t.u.	0.19	0.19	0.19
Maintenance cost—1.5%..	0.03	0.04	0.05
Operating cost...........	0.05	0.04	0.04
Total...............	0.50 c/kwh.	0.56 c/kwh.	0.61 c/kwh.
Incremental cost...........	—	0.95 c/kwh.	0.99 c/kwh.

sary to burn additional fuel in the exhaust gases in order to reduce the excess air to a more normal value. The arrangement of equipment in this case is shown diagrammatically in Fig. 7. This results in a large increase in the steam produced for any given electrical output and reduces the power obtainable for any given process steam demand. It does, however, preserve the efficiency of the boiler installation and electrical energy remains a by-product of steam production.

It is apparent that for maximum electrical output from a given amount of heat to the process, the gas turbine should be designed for maximum specific output, i.e. for minimum air flow per kwh. output. This requirement is not usually compatible with that of maximum over-all efficiency and may have a deciding influence on the selection of the particular unit to be used. From the data available it would appear that for a turbine inlet temperature of 1350°F the minimum air flow is about 60 lb. per kwh. and results from the selection of a pressure ratio of about 6:1. Assuming a normal fuel oil and an excess air of 10% at the boiler outlet this results in a power output of about 17 kwh. per million B.t.u. to the process. This figure can be compared with those of Fig. 2 for steam turbines.

The capital cost of gas turbines in sizes that might be applicable to by-product power installations range from \$100 to \$160 per kw. and complete plants might cost \$140 to \$200.

The fuel consumption per kwh. is about the same for the gas turbine operating under these conditions as for the back-pressure steam turbine, the most important losses being the mechanical and electrical losses in the unit itself and the loss in the flue gas leaving the boiler.

Among the advantages of the gas turbine over the steam turbine is the fact that full output can be obtained with no steam demand, with no special equipment and with no additional losses in normal operation. However, its limitations with respect to fuels and the relative uncertainty about its reliability have prevented its being used to the same extent.

It is possible where conditions warrant it to combine the gas turbine with the back-pressure steam turbine so as to obtain a total by-product power output slightly greater than the sum of the two separate outputs.

A further step in the application of the gas turbine involves the use of the boiler furnaces as the combustion chamber for the gas turbine. The furnace then operates under pressure and absorbs heat from the products of combustion reducing the temperature to the point where the gas can be delivered to the turbine. This cycle, which has been described in a number of papers,[3, 4] has been proposed for the generation of power only. It would be equally applicable to the generation of steam and by-product power and should result in an electrical output of about 20 kwh. per million B.t.u. to the process. It too could be combined with back-pressure steam turbines to obtain greater output. At the moment both the probable cost and the reliability of such an installation are uncertain.

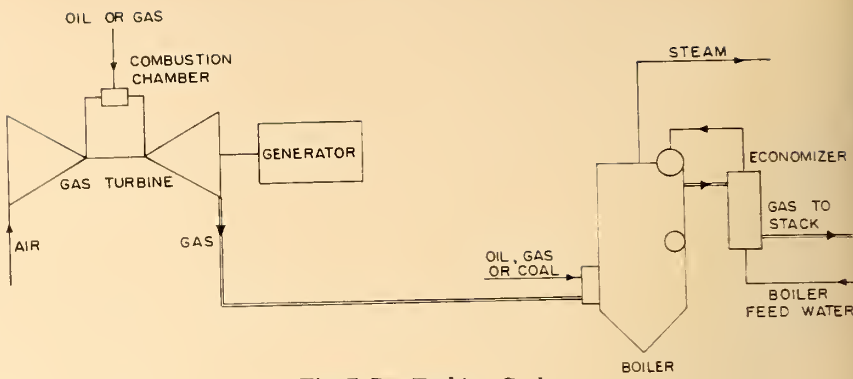


Fig. 7 Gas Turbine Cycle.

Miscellaneous Cycles

A further possibility is the binary cycle which uses mercury in a high temperature cycle and produces steam from the mercury condenser. The steam can then be used either in the generation of additional power or for process work. From the information available[5] it appears that a mercury turbine supplied with vapour at 140 p.s.i.g., 958° F and exhausting to a condenser at 1.23 p.s.i.a., 471° F would produce steam at a pressure of 415 p.s.i. and would deliver about 67 kwh. per million B.t.u. to process. Steam at this pressure could be used in some cases to generate additional power before being delivered to process.

The disadvantages of the mercury cycle seem to be associated with the very high cost of the mercury and to the metallurgical difficulties. At present there seems to be no great interest in its further development.

There are many other devices that could be applied to the generation of by-product power. An interesting, though possibly unimportant, example is the thermoelectric generator. In its most modern form this device is based on the same principle as the thermocouple commonly used for temperature measurement but has been greatly improved in efficiency and practical usefulness by the application of semiconductors. It has been used in remote areas of the U.S.S.R. to permit radio receivers to be operated from the electric power generated by kerosene lamps. Efficiencies of about 10% have been reported[6] corresponding to a power production of about 32 kwh. per million B.t.u. discharged by the lamp.

Summary

This brief outline of the methods available for by-product power generation has, it is hoped, served to call attention to the numerous possible applications of this process. While it is clear that power produced in this way is not necessarily cheap, it is equally clear that in many cases it may be very much lower in cost than alternative sources. Steam turbines are most generally applicable although gas turbines and other types of equipment have their place.

While the field of application is wide, it is evident that no great part of our power needs are likely to be met in this way, at least in the foreseeable future. It is essential, however, in view of the constantly increasing demand for fuel and power, that where such opportunities exist for the more efficient use of our resources they should be given adequate consideration.

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PHOTOGRAPHY AND ELECTRONICS AS TOOLS IN HYDRAULIC EXPERIMENTAL WORK

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The authors review recent developments in the sciences of photography and electronics, and show by means of examples how these developments can be used to advantage in hydraulic experimental work.

Introduction

FOR MANY YEARS models have been used to supplement or replace analytical methods in the design of hydraulic structures and as the magnitude, scope, and complexity of the problems encountered in the design of hydraulic works increased, engineers concerned with these problems became more aware of the advantages to be derived from experimental studies.

In many problems, the fundamental equations governing hydraulic performance are uncertain and a solution by analytical means is either impossible or extremely difficult unless drastic simplifying assumptions are made. In these cases a properly constructed and operated model can usually provide the answers in a very graphic form and at a cost which is often much less than the economics which it permits in the prototype.

The modern hydraulic model has long passed the stage of a natural scale model from which are made simple U-tube and point gauge measurements. In its contemporary form it is a complex machine yielding a whole range of results pertaining to the problem in hand. It may even be termed a hydraulic analog computer.

Although the performance of hydraulic structures can confidently be predicted from models, the predictions are nevertheless subject to certain scale inaccuracies, and to provide data on model-prototype performance relationships the model results should, if possible, be checked against prototype performance. In the past these prototype measurements have been largely restricted to observations of pressures by manometers, velocities by pitot tubes, and discharges by current meter readings. Now, due to improved experimental techniques, both static and dynamic measurements of pressures and deformations can be easily and accurately made in parts of large hydraulic structures where access difficulties had formerly made such measurements impossible.

The recent advances in hydraulic experimental techniques which now permit the solution of many intractable problems, have been facilitated largely by improved instrumentation. This improvement has been effected to a large extent by the use of instruments developed to a very high degree of accuracy in other fields of science. The two specialized fields from which the authors have drawn for the instrumentation of recent experimental work are those of photography and electronics.

Recent advances in photography are not so much new techniques as refinements in existing processes and materials. Electronics, on the other hand, is a comparatively new science which is advancing at a spectacular rate and providing an almost bewildering array of measuring instruments. The following examples show

Fig. 1 Unsatisfactory Intake Transition

how advances in both these sciences were used to obtain information required for the hydraulic design of some major projects in Canada and Pakistan.

Photographic Techniques

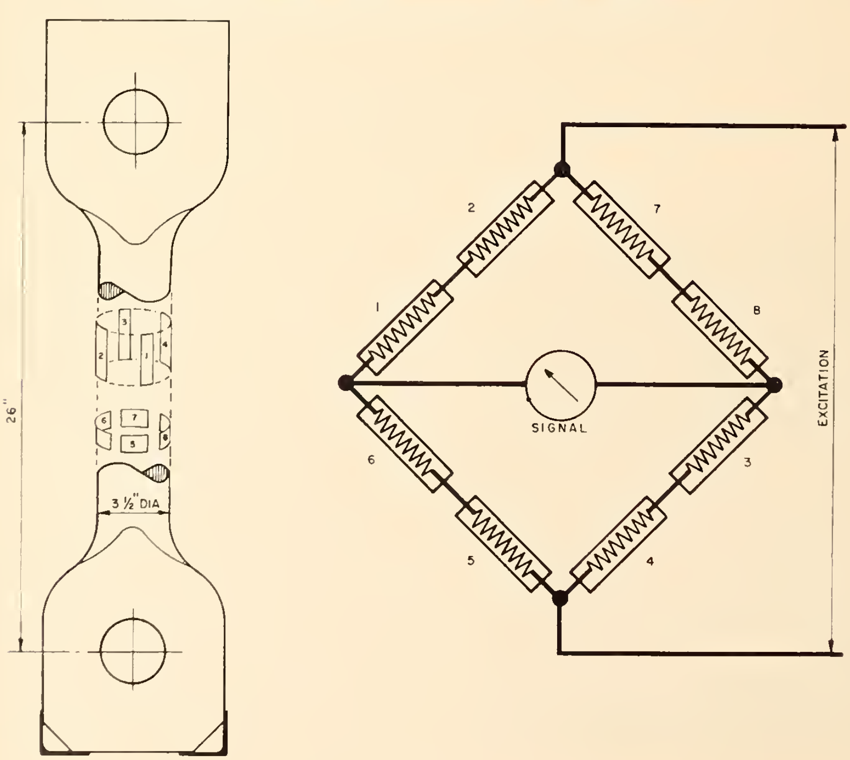
(a) Flow Mapping — The photographic methods used to record the flow in a hydraulic model of the Bersimis No. 1 intake provided an example of how improvements in an established technique could be made to yield additional hydraulic information. The intake of the 1,200,000-h.p. Bersimis No. 1 hydro-electric development in Northern Quebec, is situated on one side of the relatively shallow valley which forms an arm of the Lac Casse reservoir. The design of this intake required extensive tests in two models, the first to determine the direction and velocity of flow in the valley, and the second to determine the optimum geometry of the intake itself.[1, 2]

The scale of the first model allowed approximately three quarters of a mile of valley to be reproduced in the laboratory space available. The problem of recording the direction of flow could have been solved by photographing the tracks of floating lighted candles in a very subdued ambient light. The velocities at different points could have been measured in subsequent runs by opening the camera shutter for short measured periods. This technique has been used in many laboratories. However, as the area to be examined round the Bersimis intake was very considerable and records had to be made at several discharges, and at a number of different reservoir elevations, the above method would have resulted in a multitude of photographs and model runs.

Fig. 2 Transition Given by Shape of Free Jet

Clearly, the number of photographs and model runs could be reduced if the trails of light were punctuated at intervals so that the distance a float moved in a known interval was visible as well as its direction of movement. Further laboratory time could be saved if the lighting on the floats was provided by an external source rather than by candles. It was reasoned that if full advantage was taken of the fine grain high resolution properties of present-day film the runs could be done in normal room lighting. With modern film sufficient contrast could be obtained between the floats and the surrounding model by painting the model a dull black and providing the float tops with highly reflective surfaces.

Fig. 3 Strain Gauge Dynamometer and Bridge Circuit



The average time for the majority of the floats to run the course in the model was in the order of two minutes. The camera aperture was, therefore, adjusted so that topography of the model only just started to register in that time. With this camera aperture, the trails of the float tops were found to be clearly visible. Paper-coated aluminum foil pasted on top of the floats gave the most satisfactory trail. The distance which the floats travelled every 10 seconds was made visible on the photograph by firing flash bulbs at this time interval. The momentary increase in light intensity showed the float's position in the form of a series of bright spots on the continuous trails.

As the camera remained unmoved throughout the entire series of experiments, a preliminary set of pictures of a 12-in. grid (100 ft. in the prototype) was taken at each of the reservoir elevations to be tested, and then transferred to the final prints by double printing. This process eliminated parallax error when analyzing the prints. On one photograph there was a 100-ft. grid of the valley, and the trail of each of the 10 numbered floats. The distance and direction each float travelled between the firing of flash bulbs is clearly visible and can be measured from the photograph. The consecutive time intervals between flashes was indicated by the sweep second hand of the time clock whose images could be seen at the top of the photograph.

After the preliminary tests demonstrated the practicability of this method of recording, it became evident that an improvement would result if an electronic flash were used in the place of flash bulbs. A unit was therefore constructed using a Xenon tube with capacitors and chargers which allowed it to be fired at intervals somewhat less than one-half second if so required. Apart from a saving in cost, the extremely short duration of the electronic flash (1/2000 seconds) enabled numbers printed on the float tops to be clearly defined regardless of how fast the float was travelling.

(b) High-Speed Cine Recording—The use of a cine camera to slow down the motion of high-speed phenomena and make them visible to the naked eye, is well known. It can also be used very effectively to

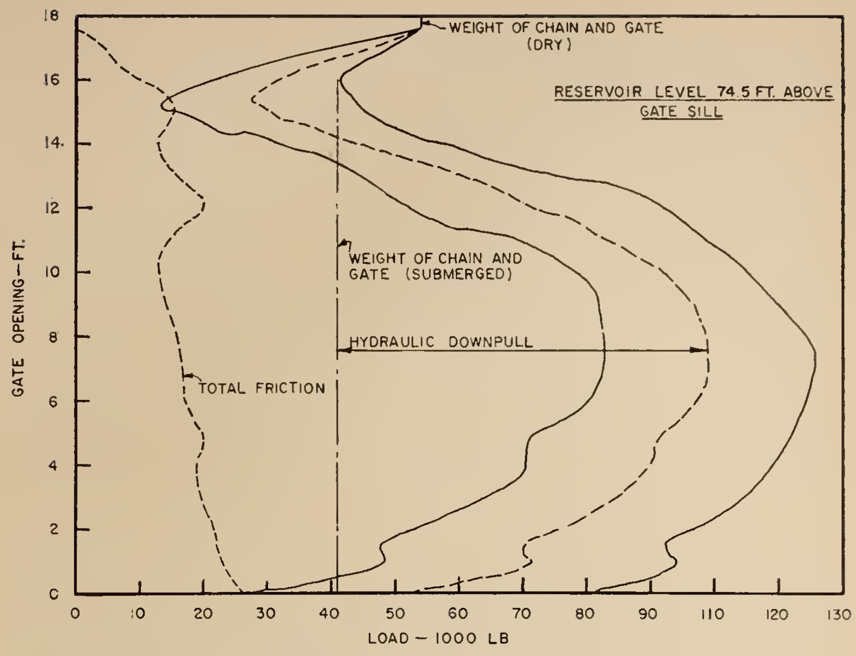


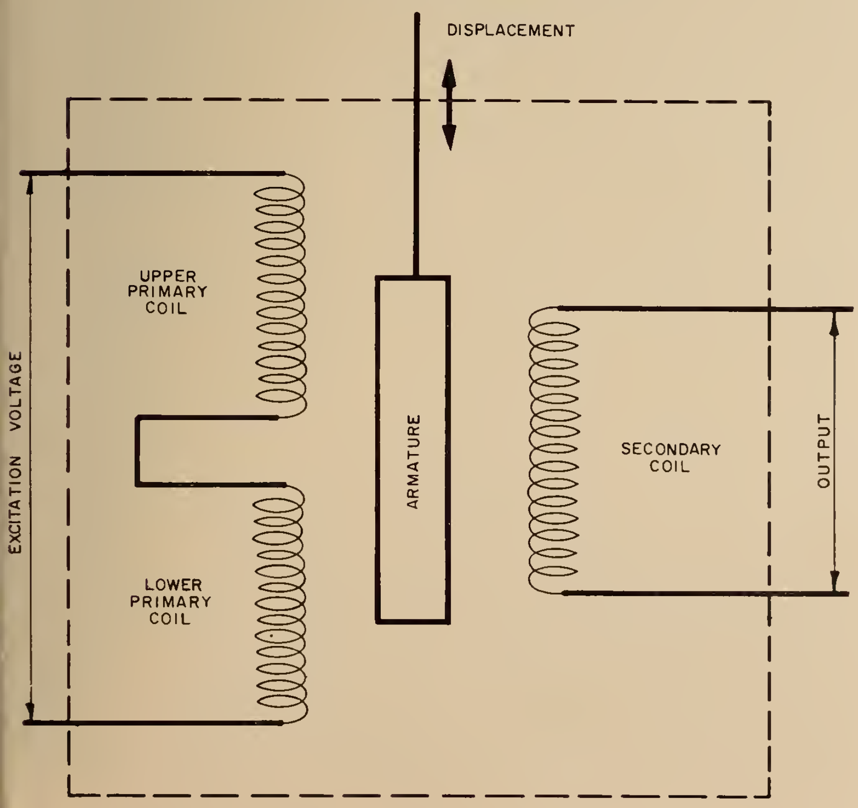
Fig. 4 Forces Required to Operate Low-Level Outlet Gates

change the time scale of hydraulic experiments. The advantage of this technique was taken in the laboratory at Niagara Falls to investigate possible failure mechanisms of a hydraulic structure. The study was made as part of the design of masonry protection to a rock-fill cofferdam which would be used for dewatering the dam construction area of the Warsak hydro-electric development in Pakistan. The magnitude of floods in the Kabul River on which this development is situated made it uneconomical to divert the entire river discharge during the flood season. The construction schedule was therefore arranged so that work on the base pours of the dam would be made only during low flow period. When the flood exceeded 30,000 cfs the cofferdams would be overtopped and work on the base section of the dam suspended.

Model tests of the typical cofferdam cross section showed that when, at the design flood discharge of 200,000 cfs an artificially lowered tailwater level was raised to a value representative of prototype conditions, the blocks representing masonry protection were suddenly washed away. Because this failure happened without any apparent warning, it was difficult to be certain what was actually taking place. The high-speed motion picture film showed that at the instant of incipient failure, the blocks were lifted off their bedding by an upward flow. As soon as one of these blocks lifted slightly above the adjacent ones, the stream flow carried it out still farther and increased the uplift on the remaining blocks, which then rose up like a blanket and were carried away by the flowing water.

Die injections revealed that the supply of water causing uplift came from downstream through weep holes

Fig. 5 Linear Variable Differential Transducer



left in the masonry protection. Piezometer measurements showed that at the design river discharge of 200,000 cfs, the static pressure from the tailwater was sufficient when combined with dynamic pressure reductions on the curved face of the cofferdam, to overcome the submerged weight of the 4 feet of masonry protection originally proposed. From these same piezometer measurements it was possible to calculate the thickness of masonry needed for a safe design.

(c) Graphic Recording—A camera can also be used as a graphic recorder and thereby greatly simplify some hydraulic measurements. During hydraulic model tests on the low-level outlets of the Lake St. Anne Reservoir, this technique was used to facilitate the experiment required to arrive at the most economic intake transition upstream from the outlet gates.

Although the model of the Lake St. Anne Reservoir outlet was constructed primarily to determine its discharge capacity and the extent of erosion downstream, one side of the model was constructed entirely of Plexiglas to allow visual observation of flow in the conduit.

Tests soon showed that a preliminary design of the intake transition using a single radius was not satisfactory. The water tended to leave this transition tangentially as shown on Fig. 1. Vibration and cavitation damage could be expected from such flow in the prototype.

To find experimentally the natural path of the water and therefore the shortest transition which would give no negative pressures over its surface, a knife edge was inserted in the model on the plane of the dam face. The issuing jet was then photographed through the transparent side of the model and an enlargement, shown in Fig. 2, made to a convenient scale. The shape derived from this photograph corresponded very closely to an ellipse[3] having the equation $x^2 + 10.4y^2 = D^2$, where D is the height of the conduit and x and y are rectangular co-ordinates. This shape was used in the final design.

The reduction in length of transition obtained from this experiment allowed a considerable saving to be made in the volume of concrete in the dam.

Electronic Techniques

(a) Strain and Load Measurements—In 1856 Professor W. Thomson (Lord Kelvin) in a paper before the Royal Society of London,[4] describing his findings on the electro-dynamic

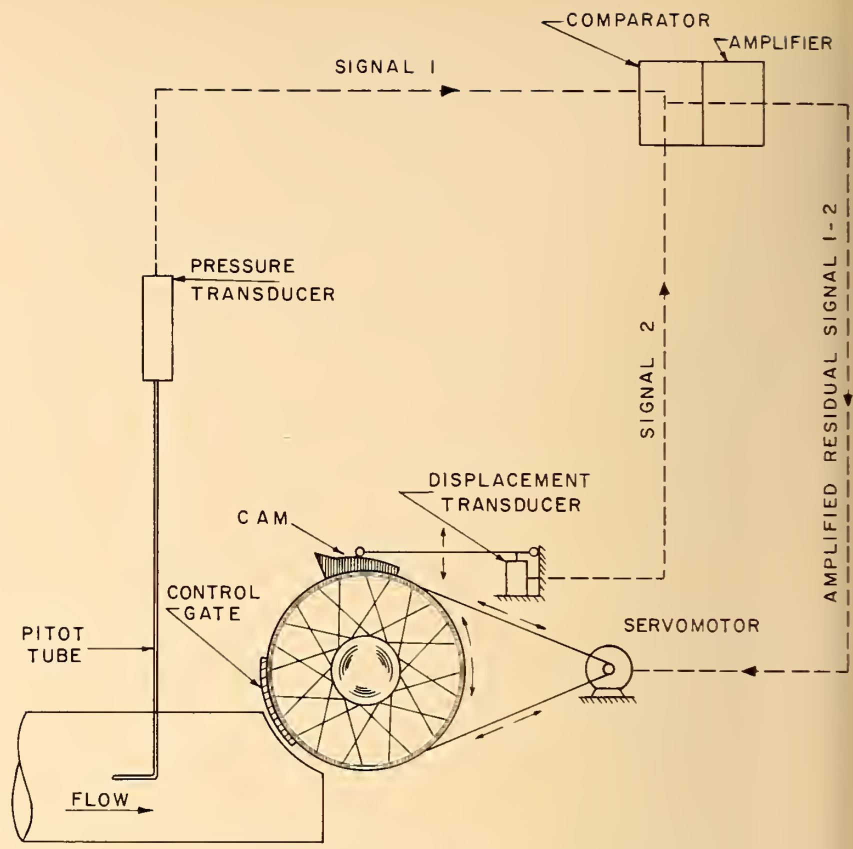


Fig. 6 Diagram of Control Gate Mechanism

properties of metals, reported that the electrical resistance of certain wires changed when they were subject to tension. More than 70 years elapsed before any attempt was made to use this phenomenon to indicate strains, and even then the early electrical strain gauges which used tensioned wires fastened to the objects under test, were expensive, highly specialized instruments which could not be used outside the laboratory.

However, in 1938, both Simmons at the California Institute of Technology and Ruge at Massachusetts Institute of Technology developed almost simultaneously a technique whereby the wires were cemented or bonded to thin paper. These bonded strain gauges could easily be manufactured in quantities, and quickly became popular with research engineers. The bonded gauge,[5] which closely resembles a postage stamp, can easily be cemented on to the surface of the object whose strain is to be measured. Most engineers have now used these gauges for measurements of strain in steel structures and are aware that when such gauges are attached to structural members, they can be calibrated to indicate the magnitude of loads acting on the structure.

The application of this technique was found very convenient when, after the Lake St. Anne Reservoir was constructed, a test was made to find the force required to operate the outlet gates. The 12-ft. wide by 18 ft. high outlet gates in this dam are operated by a chain attached to the centre of each gate. The prototype forces were measured by inserting in this chain a special link in the form of a simple cylinder with thickened ends, and by attaching strain gauges to the link. Four gauges were placed on the link to sense its elongation and four more were placed circumferentially to sense the contraction. By connecting pairs of the gauges in series the resulting four pairs were connected to form the four arms of the Wheatstone bridge circuit shown on Fig. 3. It will be noted that adjacent arms are alternately tension and compression pairs. The effect of loading the link was to unbalance the bridge with all four arms contributing to the effect. A change of temperature, however, does not disturb the balance as the change of resistance is the same in all the gauges and therefore the same in all four arms of the bridge. The possibility of a slight eccentricity of loading in the link led to the use of four tension gauges.

and to provide temperature compensation a further four gauges were necessary. As the latter have to be placed in an adjacent arm of the bridge circuit, they must either be inactive, that is, placed on an unstressed area subject to the same temperature, or active in the opposite sense, as in this case where they sense the contraction. A further significant reason for the multiplicity of gauges was the correspondingly greater signal obtained. The four leads were led to an amplifier which also supplied the excitation voltage and this, in turn, was connected to an oscillograph.

Prior to tests at the site, the link was calibrated in a mechanical testing machine by applying known loads.

The total indicated loads comprise three factors:

(a)—Submerged weight of the gate

(b) — Hydraulic downpull

(c) — The friction of the guides, rollers, and seals.

During raising the total load was the sum of all three, but during lowering the load is the sum of (a) and (b) less (c). Fig. 4 shows that the hydraulic downpull can be obtained by deducting the submerged weight of the gate from the mean operating load.

As the value of hydraulic downpull is affected by the geometry of the bottom of the gate, opportunity was taken at the site to observe the effect of a temporary modification to it. The gate was hauled up on the deck, the modification made, and the test repeated. The entire program, including additional runs to find the starting friction was completed in one day.

(b) Pressure and Movement Transducers — The foregoing description shows the use of strain gauges as a means of measuring forces. If, however, the gauges are fixed to a relatively thin walled vessel subject to fluid pressures, we have another form of transducer and a means of observing and recording pressures. Again, if gauges are applied near the supporting end of an elastic cantilever and the unsupported end is caused to follow a displacement, we have the basis of a displacement transducer. Frequently, the cantilever system is used to measure the displacement of a bellows or diaphragm and thus provide a more sensitive pressure transducer.

However, displacements and indirectly, pressures, can also be measured electrically by an entirely different principle which has definite advantages in certain circumstances where a greater electrical output is required. This unit is known as the linear variable differential transformer commonly abbreviated to LVDT or differential transformer.[6]

An LVDT, Fig. 5, consists essentially of two primary coils, a secondary coil, and an armature of magnetic material. The primary coils are energized from a suitable source of alternating current and connected in series so that their flux is opposing. If the two primary coils are identical and the armature is located so that it receives an equal amount of flux from each, the output of the secondary coil is theoretically zero.

Motion of the armature towards the upper primary coil results in a linearly increasing output of the secondary coil. Similarly, movement towards the lower primary coil again results in an increasing output, but with the opposite phase. Depending on the dimensions of the transformer, it can be made to measure movements ranging between a foot or more and less than a tenth of an inch in each case with an accuracy of one-tenth of one per cent.

(c) Electronically Controlled Dynamic Models — An example of the comprehensive use of electronic techniques in hydraulic model experiments is provided by a recent hydraulic study to establish the minimum stable diameter for the surge tank of the 855,000-h.p. Bersimis No. 2 hydro-electric development currently being constructed in Northern Quebec. To accomplish the purpose of the test, the model had not only to reproduce the inertia and flow resistance of the prototype supply tunnel and the action of the orifice surge tank, but also had to regulate the model discharge so that it varied with the surge height in a manner corresponding to the prototype turbines supplying a constant load under transient hydraulic conditions.

When designing this model it was known that the problem had already been approached in two different ways. The first[7] was to distort the supply tunnel and surge tank scales so that the period of surge oscillations was increased to an extent that the flow could be controlled manually by an operator watching a pressure indicator. The second[8] used a spring-balanced disc in a throated discharge tube. For the Bersimis No. 2 development both these methods were open to objections which could be overcome by electronic control of the outlet valve. The accuracy of response of an electronic controller could be made to suit the very rigid requirements of this model study and could easily be designed to incorporate the non-linear functions required to represent the droop in turbine efficiency curves near full load.

The control gate system of the Bersimis No. 2 surge tank model is shown diagrammatically in Fig. 11. The head at the outlet gate actuated the diaphragm of a pressure transducer operating on the differential transformer principle already referred to. The output of this pressure transducer is, therefore, an electrical signal in which the voltage varies directly with the pressure. This signal was fed into one side of the comparator.

To represent in the model a particular station power output, any instantaneous value of head had to have associated with it a corresponding outflow and therefore a singular position of the control gate. When, due to surges the head changed, the position of the control gate had also to change so that at all times it metered a flow corresponding to that for constant station power output, and the instantaneous value of the head.

Attached to, and rotating on the same axis as the control gate was a cam followed by a displacement transducer also operating on the differential transformer principle. The voltage of the signal from this transducer varied with the lift imparted by the cam and was therefore a function of the gate position. The cam was shaped so that when the signals from the pressure and movement transducers were fed into opposing sides of the comparator, it gave a null output when the discharge and head were correctly related for a particular power output. If during a test there was a change in model head, the balance just referred to was disturbed and the comparator emitted a voltage, the magnitude of the voltage depending on the magnitude of the error, and the direction depending on the sign of the error. As indicated in the diagram, this voltage was fed to a heavy duty amplifier the output of which was led to a reversible low inertia servomotor. The control gate was therefore driven towards its correct position by the error signal from the comparator, the gate position function being fed back. The control thus constituted a closed loop system constantly seeking the balance or null point.

(Continued on page 79)

THE USE OF FLY ASH IN CONCRETE BY ONTARIO HYDRO

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

This paper is a resume of Ontario Hydro's experiences with the use of fly ash as a partial cement replacement in grouting mixtures and concrete. Field trials have shown that fly ash, because of its pozzolanic properties, can be used to replace substantial percentages of the cement in normal concrete mixes and grouts without adversely affecting, and usually enhancing, the long-time strength attained. Fly ash was also found to (a) reduce the temperature rise in the concrete, thereby lessening the danger of thermal cracking in massive sections; (b) enhance the workability of concrete and grout; (c) provide a somewhat increased setting time, thereby producing concretes and grouts that remain workable for a longer period, and (d) in most instances provide economies. The use of fly ash in both high- and low-pressure grouting mixtures at Niagara and to replace from 20 to 30 per cent of the cement in appropriate mass and structural concrete applications at the Ontario Hydro's St. Lawrence, Caribou, Whitedog and Otter Rapids projects are described. An account is also included of the method developed for batching the ash as a slurry.

FLY ASH is the finely divided residue resulting from the combustion of pulverized coal, as used in many modern steam-generating stations. It is usually collected before reaching the stack by means of electrostatic or mechanical separators or both, and is composed mainly of silica, alumina and iron oxide. It is one of a number of powdered materials having pozzolanic properties, i.e., cementing ability when combined with lime, in the presence of moisture. From early time it has been known that certain finely divided siliceous materials of volcanic origin exhibit cementing properties when mixed with lime. Such substances were used in Italy about two thousand years ago and many of the early structures in which they were used are still standing. This volcanic ash was called "pozzuolana" after the Italian town of Pozzuoli, adjacent to the ash deposits. The term pozzolan has come to mean any activated siliceous or siliceous and aluminous material, natural or artificial, processed or unprocessed, which though not cementitious itself combines readily with lime in the presence of water to form a cementitious compound. The use of pozzolans (both natural and artificial) as replacements for part of the portland cement in mass concrete has come into prominence in recent years. Pumicite, for example, a naturally occurring pozzolan, was used by the U.S. Bureau of Reclamation in the mass concretes for the Friant and Altus Dams, a pulverized calcined siliceous shale was used in the concrete for the Davis Dam. Fly ash also has been used in the mass concretes of many dams including the Hungry Horse, Canyon Ferry and Palisades dams of the U.S. Bureau of Reclamation.

In addition to such use in mass concrete, fly ash has found widespread use in the concrete block industry, ready-mix concrete, structural concrete, masonry cement and cement grouts. Although cost reduction is usually the main motive, technical advantages are also very often achieved. Among the confirmed advantages in the use of fly ash in concrete under proper control are higher strengths, reduced permeability, reduced temperature rise (mass concrete), enhanced workability, reduced mixer and mould wear (masonry units), increased green strength (masonry units) and enhanced sulphate resistance. On the other hand concrete containing fly ash should be carefully controlled to minimize disadvantages such as reduced early strength and increased setting time. The former may necessitate a longer curing period before the concrete is loaded. The increased setting time could cause increased form pressures and therefore call for a lower rate of placing or strengthened forms. On the other hand, an increased setting time can be advantageous in certain circumstances.

Not all ash that is trapped in precipitator systems is necessarily of satisfactory quality, although the ash from the larger furnaces using pulverized coal are most likely to be satisfactory. Ash meeting the requirements of ASTM Specification C350-57T can be considered suitable, since the specification covers composition, fineness, strength performance and other desirable characteristics.

Ontario Hydro's interest in the use of fly ash was initially stimulated several years ago when the lack of low or moderate-heat cement for mass concrete made it desirable to blend a pozzolan with normal cement to prevent excessively high temperatures. Also, when its first fuel-electric generating stations were being built it was known that they would soon be producing a useful by-product which, if suitable markets were encouraged, could lead to a reduction in the cost of power generated from solid fuel. Accordingly, a substantial body of data on the behaviour of fly ash concrete was accumulated by the Commission's laboratories over the past few years with a view to promoting the utilization of this by-product.

These studies clearly pointed to applications of technical advantage and the Commission, therefore, did not wait until it was collecting ash from its own plants before making successful use of fly ash as a component of cement grouts and concrete at several of its major hydraulic developments such as the Niagara, St. Lawrence, Whitedog and Caribou Power Projects.

Before dealing with the specific applications of fly ash at these Commission projects it is proposed to review briefly the extent to which fly ash affects some of those properties of concrete, which were of importance in Commission applications of fly ash.

Properties of Fly Ash Concrete

As mentioned earlier, the main reason why fly ash has found use as a partial cement replacement is, of course, its pozzolanic property, i.e., its ability, in the presence of water, to react with the free lime liberated during the hydration of Portland cement to form an additional cementing material. Because of this, some fly ashes may be used to replace up to 50% or more of the cement in thoroughly cured normal concrete mixes without adversely affecting the long time strength attained and in moderate percentage replacements effecting a considerable increase in ultimate strength. Strength development at early ages is slower however, and for this reason it is seldom feasible to take advantage of the maximum cement replacement that would be feasible on the basis of equal long-term strengths. This is demonstrated in fig. 1 which shows age/strength relationships for two different fly ashes at various percentages of replacement. It is readily noted that the strength behaviour of fly ashes from two sources are significantly different. This difference is considered to be due primarily to fineness, the finer ashes producing the more rapid strength development.

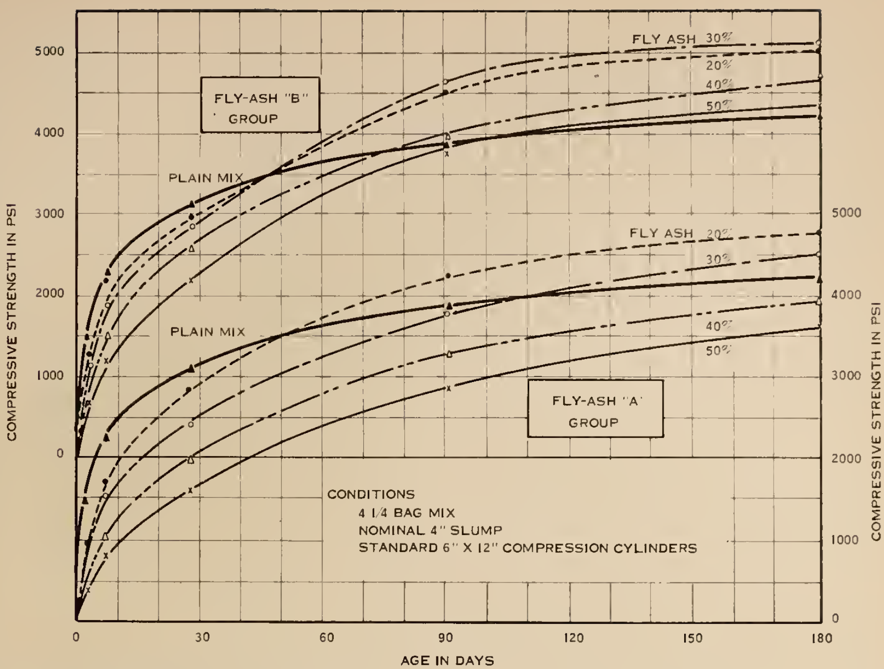


Fig. 1 Age-strength relationship of concretes with various percentages of cement replaced by fly-ash.

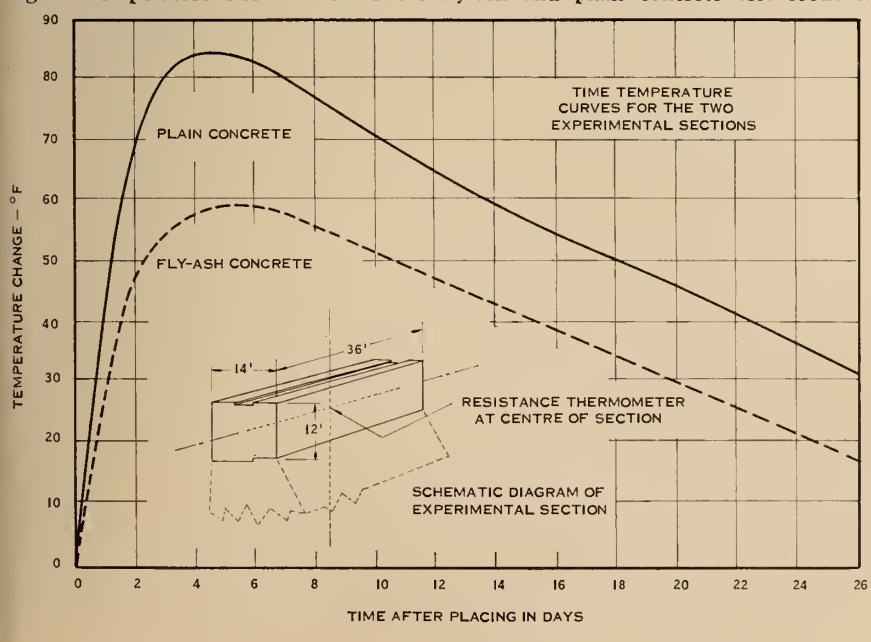
The effect of ash fineness on strength development is further illustrated by the following data on the compressive strengths of nominal 5½-bag concretes using ashes of different finenesses (obtained by blending a fine and coarse ash).

Fly Ash Fineness * (sq cm/gm)	Compressive 28-Days	Strength 91-Days
2305	2570	3550
3620	2750	4080
5445	2940	4140
7625	3300	4510

It may be seen that both the 28-day and 91-day strengths increase as the fineness increases.

A desirable property of fly ash concrete connected with its slower strength development is its lower temperature rise. In massive structures it is desirable that the rise in temperature due to heat evolution not be excessive so that the stresses resulting on cooling of the mass are less likely to produce cracks. There are extensive data to show that temperature rise in massive concrete structures is much less when fly ash is used to replace part of the cement. Figure 2 shows time-temperature curves for two experimental blocks of concrete (12 x 14 x 36 ft) placed in the Commission's Otto Holden Dam, one being made of 6-bag plain concrete and the other having 20% of its cement replaced by fly ash. It can be noted that the peak temperature was reduced by about 25F or approximately 30% in the fly ash mix.

Fig. 2 Temperature rise curves for the fly-ash and plain concrete test sections.



* Fineness is usually expressed in terms of the total surface area of the particles (sq cm/gm) determined with the Blaine air permeability apparatus.

Fig. 3 shows the strength development curves for these concretes and it can be seen that from the age of 15 days the fly ash concrete exhibited considerably higher strength.

Another property of fly ash concrete connected with its slower strength development is a somewhat increased setting time. This too can be advantageous in mass concreting operations where a large area of concrete is exposed and it is desirable to "keep it alive" until the succeeding layer is placed on top. Temperature, of course, also has a great effect on rate of setting of concrete. The extent to which fly ash affects the setting time at two different temperatures is demonstrated in Fig. 4. In this illustration the setting behaviour of the concretes was followed with the Proctor needle, measuring the resistance to penetration offered by the concretes at various ages. A penetration force of 500 is considered to be the limit beyond which concretes are no longer workable. In practical terms then, it appears that a 25% cement replacement by fly ash will produce concrete that "stays alive" approximately two hours longer at 70F and approximately four hours longer when the concrete temperature is 50F.

The properties of fly ash concrete discussed in the foregoing paragraphs, i.e., strength development, temperature rise and setting characteristics along with the enhanced workability that fly ash imparts to concrete were the main considerations in the Commission's applications of this material.

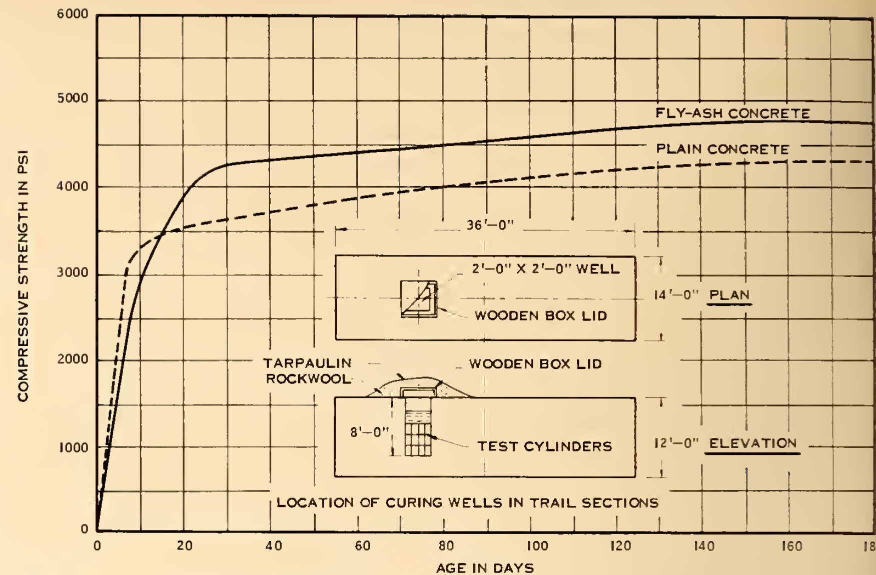


Fig. 3 Age-strength relationships of test cylinders of plain and fly-ash concrete used in experimental sections of Otto Holden Dam.

Commission Applications of Fly Ash

Nine years ago, fly ash was used on a trial basis in one block of the Otto Holden dam for direct comparison with a block of regular concrete. Strength and temperature rise characteristics of this concrete were discussed in the previous section. Repeated examinations of the Otto Holden dam since that time have shown no deterioration of any kind in the fly ash concrete even at the water line where weathering conditions are the most severe. This was convincing evidence of the durability of fly ash concrete without which it might never have been used in such an important a structure as the St. Lawrence Powerhouse. It speaks well for the foresight of those who instigated the tests at Otto Holden, many years before fly ash became available from steam generating stations within the Province.

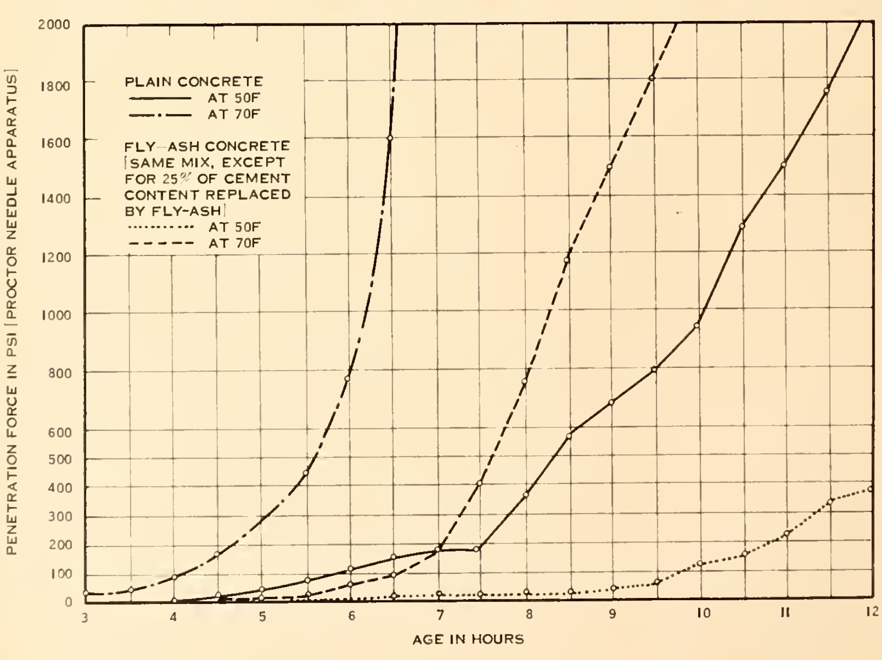
Niagara (Sir Adam Beck No. 2) Project

The first place fly ash was used extensively by the Commission was at Niagara Falls for grouting the small spaces between the rock and the concrete lining above the arch of the two 5-mile tunnels. It was also used in the high pressure grouting of the rock surrounding the tunnels. There were three reasons for deciding to use fly ash in grouting. First, by retarding the set and reducing sand settlement it facilitated the pumping of grout through the long lines of pipes from the surface; second it has cementing characteristics previously described, and third it increases the "flowability" of the grout because of its fine spherical particles. There were two grout mixes used, — low pressure sanded grout 1:1:3 cement:ash:sand, with a water-cement ratio of 0.80, and high pressure grout 3:1 cement to ash with a water ratio of 0.55. Both of these mixes pumped exceedingly well even though they travelled some 1500 ft. and were repumped before they arrived at the required location.

St. Lawrence (Robert H. Saunders) Project

Another application for fly ash concrete came on the St. Lawrence Development, where during the design stages it was found necessary to span the 80-ft. ice sluices with beams

Fig. 4 Rate of setting of plain and of fly-ash concretes at two temperatures.



about 28 ft. deep to carry the 300-ton gantry crane. Fly ash was considered the solution for the thermal shrinkage problems which were inevitable in such massive structural members.

Twenty-five per cent of the cement was replaced with fly ash in these beams and this resulted in a corresponding decrease in temperature rise and thermal shrinkage, which minimized the danger of cracking in the beams.

The concrete of the powerhouse was composed of crushed rock, manufactured sand and portland cement, and it was found that the fine spherical particles of the fly ash seemed to give the concrete additional "lubrication" or response to the vibrator. It also appeared to stay "alive" longer than ordinary concrete of the same temperature. For these reasons it was used in the heavily reinforced and difficult pours around the scroll case and also in the scroll case roof where it minimized shrinkage to such an extent that although they were placed in eight segments, none of the scroll case roofs leaked under full head.

Fly ash particles being lighter and frequently finer than cement, tend to create a dust nuisance when bagged fly ash must be batched manually into the mixer. Normally, of course, this does not constitute a problem in batching plants equipped with a separate storage silo and batching hopper for the bulk fly ash. At the St. Lawrence project where no facilities were provided for storage and batching of bulk fly ash, the material had to be shipped and stored in bags. To alleviate a dust problem, the fly ash was mixed with water in a building entirely separate from the mixing plant. (See Fig. 5). A standard grout pump then delivered the slurry to the batching floor of the mixing plant, where by simply turning a valve, the batcher at the control board could add any specified quantity to the mixing water by watching the dial on the water tank scale. The proportions of ash to water were standardized at one to one by weight which gave a very pumpable slurry. To arrive at the mix proportions, the inspector at the plant had only to deduct the amount of water in the fly ash slurry from the total mixing water, which was calculated easily because of the simple ratio maintained in the slurry mixture. When the slurry was not being drawn off at the concrete batching floor, it was automatically recirculated to the grout pump by means of a two-way valve, thus maintaining the ash in

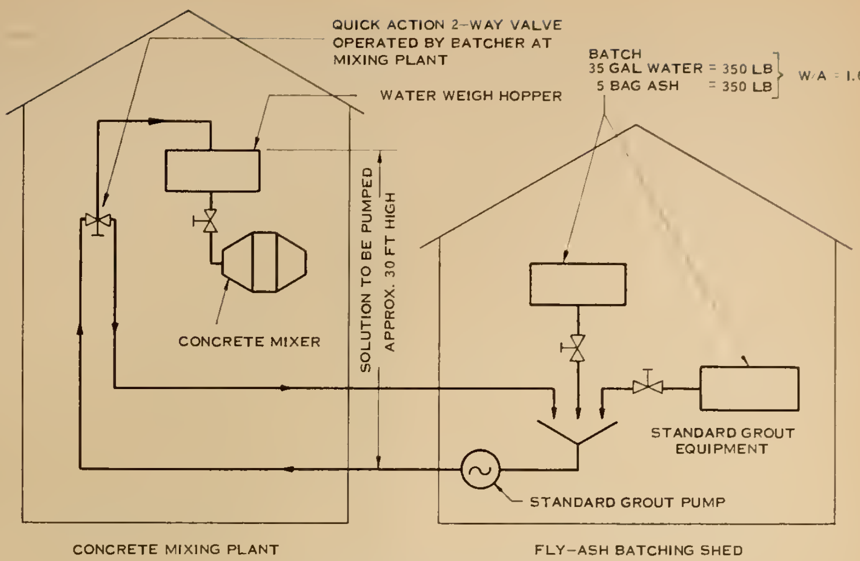


Fig. 5 Fly-ash handling equipment.

suspension. As there was no setting action of the ash in water, the mixture could be recirculated almost indefinitely. Even though the mixing plant inspector was in a separate building from the batching of the fly ash, any error in the fly ash slurry proportions could be quickly detected by checking its specific gravity with an hydrometer.

Thus there were two completely independent operations, the men in the fly ash shed being concerned only with maintaining an ample supply of uniform slurry, and those in the concrete plant having only to turn a valve and draw the ash off when it was required. (See Fig. 7). This had many advantages:— it kept all of the dust out of the mixing plant; it did not interfere with the simultaneous production of regular and fly ash concrete for different parts of the job; and the premixing of part of the cementing agent in water had certain basic advantages from the standpoint of control and thoroughness of mixing.

Whitedog and Caribou Projects

Each of these stations had three generating units, the scroll case roofs of which were about 50 x 50 ft. with a 20-ft. diameter central opening for the turbine. Normally these roofs are placed in four segments diagonally opposite segments being placed simultaneously with a two-week cooling period before placement of the other two segments. This procedure would have involved a total loss of about three months of valuable time for the two projects, to say nothing of the cost of bulkheads, waterstops and drains. Therefore it was decided to place the whole roof of each unit as a monolith, utilizing fly ash to minimize the thermal shrinkage and to assist in keeping the large area "alive" during the placing. In these pours fly ash was used to replace 25% of the cement. A water-reducing retarding admixture was also used in this concrete to lower the water requirement and to ensure proper control of the amount of retardation.

In spite of extra ingredients in the mix, concrete of remarkable uniformity was produced, and cold joints were avoided. The slurry method of handling the fly ash was used at both of these projects, and since it was not convenient to add the slurry to the water hopper at the Caribou plant, a separate measuring tank with an agitator was successfully installed on the batching floor of the mixing plant.

Otter Rapids Project

During May of this year concreting started for the Otter Rapids Generating Station on the Abitibi River south of James Bay. It will be the first hydraulic structure which the Hydro has placed in relatively shallow lifts, and since this practice increases the danger of thermal cracking, fly ash is being used as a partial cement replacement to keep the temperature rise to a minimum. The ash is being obtained from the mechanical and electrical precipitators at the Hydro's R. L. Hearn Generating Station in Toronto and is shipped to Otter Rapids in bulk cars at a considerable saving over the cost of cement. At the job, the ash is stored in a silo and added to the mixers as a slurry which is produced as previously described for the St. Lawrence Power Project where the method was first introduced. At

Sulphate Resistance of Concrete
LT-1—Ordinary Concrete
LT-2—Ordinary Concrete
LT-3—Ordinary Concrete
LT-4—Fly Ash Concrete

Otter Rapids the fly ash will comprise 30% of the cementing material in the mass concrete.

Conclusions

Because of the successful use of fly ash as a cement replacement in the past at the Otto Holden, Niagara, St. Lawrence, Whitedog and Caribou Generating Stations and the present use of our own fly ash from the Hearn Steam Generating Station in the concrete at Otter Rapids, it can be concluded that there are many structures in which fly ash can be used with assurance to facilitate the placing of concrete while at the same time enhancing its thermal characteristics and providing significant economy.

DISCUSSION

Author's reply

As yet, the only coal-burning generating station in Hydro's system that has facilities for dry storage and loading of fly ash is the Richard L. Hearn G.S. in Toronto. These facilities were completed only in the late spring of 1959. Acordingly, few data are available to date on the uniformity of fly ash after it has been drawn from a large number of precipitator hoppers (both electrostatic and mechanical types) and blended in large storage silos. However, periodic sampling from various hoppers over the past several years has indicated that while rather large variations may occur during periods when the furnaces are being started up or shut down, much greater uniformity and a higher level of quality exists when the plant is operating at or near full load. The best estimate that can be made to date of average properties of the ash produced at the Hearn station, Table A, shows it to be fully acceptable according to ASTM specification C350-57T, *Fly Ash for Use as an Admixture in Portland Cement Concrete*. At the station in question, fly ash is separated from the discharge gases in two stages. For each of the eight generating units, cyclone-type mechanical separators first trap the coarser fraction of the tiny particles while two banks of electrostatic precipitators in series entrap the extremely fine particles which have escaped from the mechanical collectors. Because of a flexible handling system, fly ash from each of a multitude of collector hoppers can be selected and discharged in the desired sequence for blending in a large storage silo to achieve a uniform commercial product. Alternatively, sub-standard fly ash which may be produced occasionally, as during start-up periods, can be delivered into a second silo for non-commercial disposal. Accordingly, future users of fly ash from this station may be assured of receiving a product meeting an accepted standard of quality.

PROPERTIES OF FLY-ASH FROM R. L. HEARN GENERATING STATION

Analysis	R. L. Hearn G.S.	ASTM C350-57T Specification
SiO_2	42.0%	
Al_2O_3	20.6%	70.0% Min.
Fe_2O_3	23.8%	
MgO	1.4%	3.0% Max.
SO_3	0.8%	3.0% Max.
CaO	2.8%	—
H_2O	0.4%	3.0% Max.
Loss on Ignition	8.3%	12.0% Max.

Fineness (Blaine Method)
Mechanical Collector Ash —3350 sq. cm/gram = 2800 Min.
Electrostatic Precipitator Ash—7570 sq. cm/gram

Sulphate Resistance of Fly Ash Concrete

Experience in Ontario with sulphate-bearing groundwater is naturally far more limited than is the case in the Prairie Provinces where sulphates occur frequently. So far, as Ontario Hydro is concerned, sulphates in serious concentrations have been encountered only in two locations.

In one instance in South-western Ontario, sulphate concentrations of 1000 to 150 ppm of SO_3 were detected in a water-bearing gravelly layer immediately overlying the bedrock at 80 to 90 ft. below the surface. Soluble sulphates in clay immediately above the gravel layer were 1300 to 6000 ppm. Subsequent construction in this area did not require the installation of concrete in this ground although concrete piles had been contemplated at one stage in the investigation.

At another location in the south-central part of the Province, drainage from a large storage area for bituminous coal was found to have pH values ranging from 8.0 to as low as 2.5 and widely-varying sulphate contents averaging from 100 to 6000 ppm. Minor concrete structures in the drainage path were found to have suffered damage which was limited mainly to surface attack to depths of 1½ in. after service periods as great as 40 years. In 1950, a limited exposure program was initiated in which specimens of ordinary and fly ash concrete made from normal portland cement were immersed in the sulphate bearing groundwater as it was collected in a drainage channel. The results to date, as illustrated by Figure 1 have indicated appreciably superior resistance of fly ash concrete. The condition described appears to be a rather unusual one for this area since examination of several other coal storage locations has failed to disclose such severe conditions. Also, the area most severely affected is restricted to a radius of a few hundred feet owing to the effects of dilution and reactions with soil components. However, in other countries, water draining from coal mines and coal bunkers is known to have damaged concrete, particularly when coal has a high pyrite content.

The Effect of Fly Ash Concrete on Form Pressures

It is true that the fly ash has a retarding effect on the stiffening of fresh concrete; the amount of retardation varying with the percentage of cement replaced by fly ash and the temperature of the concrete. During hot weather the "slowing of the set" is usually beneficial, particularly in massive concrete; and during cold weather, when the materials have to be heated to prevent freezing, its effect can be offset by raising the placing temperature a few degrees. Although the exact relation of "rate of stiffening" to form pressures has not been established, using the ACI Committee 622 from pressure's formula, it can be calculated that raising the placing temperature ten degrees (from 55 to 65) will offset the effect of a replacement of 30 per cent of the cement with fly ash. At lower temperatures the retarding effect is more pronounced requiring a greater increase in the placing temperature or a strengthening of the forms.

PHOTOGRAPHY AND ELECTRONICS . . .

(Continued from page 73)

In addition to the above general description, it can be seen from the photograph that the model discharge issued from a penstock which was tapered in plan and controlled by a form of taintor gate constructed by supporting a curved plate between a pair of light wire spoke wheels. To ensure rigidity and as a precaution against vibration, both the bearings for the wheels and the penstock chute were mounted in a heavy steel framework. The cam is mounted at the top of one of the wheels and the LVDT is actuated by a cam follower. The impact tube in the penstock feeds the total head into the diaphragm of the pressure transducer shown on the bottom left-hand corner of the photograph. As mentioned above, both the transducers were of the linear variable transformer type. The primary windings of both were excited from the same 100-volt supply.

Modifications to the size of the model surge tank were quickly made by placing displacer blocks inside a master tank built larger than the maximum size to be tested. The rise and fall of the water surface in the tank was visible through a transparent panel in the side of the tank. The period of the surge was approximately 14 seconds. Modifications to the station output could be simulated by changing the cam attached to the control gate.

During tests, the control gate was first locked for some minutes at its equilibrium position, then, by means of a mechanical clutch in the drive between it and the servomotor, the system was brought under "governor control". If the resulting oscillations progressively increased the size of tank was below the critical and the tank unstable. If they did not increase, the "governor" was declutched and the control gate moved away from its equilibrium position. Bringing on governor control from this position simulated a station load change and the model accurately reproduced the resultant surges whose damping characteristics could then be studied.

To facilitate observation of surges and to give a permanent record, the output of a second pressure transducer was applied to an oscillograph. Testing with this apparatus proceeded very rapidly. Four tank sizes could be tested at two different station outputs in one morning and the model, in spite of its complexity, more than paid for itself since the results showed that stable operation would be achieved with a prototype surge tank smaller than that which would have had to be adopted if the design had been based on classical analytical studies.

Conclusions

Experience in the operation of a hydraulic laboratory and in conducting prototype tests has shown the authors that the full benefits of experimental work in hydraulics cannot be obtained without the aid of techniques developed in other fields of science and engineering.

The examples described show how modern techniques and instrumentation may be applied to extend the scope of some hydraulic experiments and give increased information about the hydraulic phenomena involved.

Acknowledgments

The data concerned with the two Bersimis developments and the Lake St. Anne Reservoir was made available by the Quebec Hydro-Electric Commission and that concerned with the Warsak development, by the Canadian Department of Trade and Commerce. The detail design of these developments was performed by H. G. Acres & Company Limited, Consulting Engineers, of Niagara Falls, and the model tests were conducted in their laboratory. The authors are indebted to the above for their permission to give this paper. They are also indebted to their colleagues for help and care in performing the experimental work described, to Canadian Vickers Limited for supplying and calibrating the link used to measure hydraulic downpull at Lake St. Anne Reservoir, and to G. Kelk and Company Limited for assistance in the design and construction of the electronic components for the surge tank model's control gate.

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SOMETHING CAN BE DONE ABOUT NOISE

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Noise is unwanted sound—The sound of my radio or T.V. receiver is wanted by me but not by my neighbour. It may be music to my ears; it is noise to his. The roar of a motor at midnight may be a most welcome sound to the ears of the owner who has been trying for some time to get it started with a rapidly expiring battery; it is very definitely noise to all of us who are wakened out of a sound sleep by the disturbance as it enters our bedrooms. Noise is unwanted sound.

SOUND IS A DISTURBANCE initiated by mechanical vibration and propagated out from the source at a velocity determined by the nature of the medium. The medium may be a gas, a liquid or a solid — any medium characterized by elasticity and mass. However, most of the sounds that constitute a problem to us are propagated through air — they are air-borne sounds. It is important to remember that the source of all sounds is vibration — sometimes periodic and at a definite frequency; sometimes explosive or in the form of a shock, rising rapidly to a peak value and then dying away. Examples of both types of source are found in the production of human speech sounds; in the instruments of an orchestra or in an industrial plant. The amount of energy involved in the sound depends upon the amplitude of the vibrations and the area of the moving part. The greater the amplitude, the farther the air in contact with the moving part is pushed from its equilibrium position; i.e., the greater the compression and hence the greater the sound pressure. The greater the area in motion, the greater the volume of air compressed and the greater amount of mechanical energy converted to acoustical energy to be radiated away as a sound wave.

If a part of a machine is in simple harmonic motion at a high speed, the sound produced may be a relatively pure musical note. I say relatively pure because there are always some harmonics present and it is in fact the presence of the harmonics which enables us to distinguish between different musical instruments playing, say, middle C. In stringed instruments, the string which is the source of the sound may be struck as in the piano, plucked as in the guitar or bowed as in the violin or 'cello. The frequency of the note depends on the length of the string, its mass, elasticity, the tension on it. The volume of sound produced depends on the amplitude of vibration of the string and on the area set into motion by the vibration of the string. Clearly the string itself could not move much air, but the string is attached to a sounding board — the body of the violin or 'cello or guitar which by responding to the vibrating string modifies the tone but also greatly enhances the volume. Examination of other instruments used in an orchestra or band as e.g. the wind instruments or the percussion instruments bring out the same points — something is set in vibration and a sound is produced which has a fundamental or lowest frequency usually controlled by the player; a quality which is peculiar to the instrument and may depend on the manner of initiating the vibration as e.g. compare the tone of the single reed clarinet with that of the double reed oboe, and a volume depending partly on the player but also on the area of the vibrating part.

To sum up—

1) Noise is unwanted sound
2) It is generated by some vibrating body
3) The acoustical energy involved depends on the amplitude and area of the vibrating part.

The Effects of Noise on People

Most people are startled and annoyed by a sudden loud sound. On the other hand if a noise is sustained hour after hour, day after day, our reaction depends very much on whether the noise intefers with what we want to do. We may be annoyed or frustrated and both of these reactions may make us tired or tense; if this condition is continued over a period of time it may have definite physical effects. But our reactions to noise depend markedly also upon the nature of the noise and its intensity; whether it is high pitched or low; steady or intermittent; whether it makes speech communication or the use of the telephone difficult. Some noises can in time result in temporary or permanent, partial or total loss of hearing. To understand these effects better, we must know something about the hearing mechanism in man — the ear itself.

The hearing sense and the anatomical structure which enable us to hear have of course evolved with man over the millions of years. Acute hearing still has a very marked survival value. How much more must this have been true when man lived a more rugged life with his physical existence threatened by enemies on every side. Those with poor or impaired hearing did not survive; those with acute hearing passed on this characteristic to their offspring. The result is a hearing mechanism that is not only incredibly sensitive but amazingly versatile.

A functional schematic of the anatomical structure of the ear is shown in Fig. 1.[1, 2] The main features are the outer, middle and inner ear; the link motion mechanically connecting the relatively large eardrum to the small oval window at the entrance to the cochlea; the cochlea itself, filled with liquid. The three tiny bones (ossicles) which provide the linkage between the eardrum and oval window, make possible the energy transfer from the outer to the inner ear

The ear receives and responds to air-borne, acoustic vibratory energy over a frequency range of about nine octaves and a dynamic range of more than one million to one. Its output is nerve impulses in the auditory nerve. These impulses convey auditory information to the brain. We are not here concerned with how acoustic energy stimulates these nerve impulses or with the way in which the inner ear performs a partial acoustic analysis of sounds with respect to their pressure, frequency or time of arrival. All these are problems of the physiology of hearing. For the purposes of noise control it is enough to know that the outer ear conducts acoustic energy to the middle ear and that the middle ear serves as an impedance-matching device to deliver the energy efficiently to the inner ear. We also know that the inner ear may be harmed by certain diseases and also by excessive noise.[3]

Although the ear is an exceedingly sensitive device, it is not equally sensitive at all frequencies nor do all ears respond over the same frequency range. An average young ear which we shall refer to as having "normal" hearing, can detect sounds from about 20 cycles per second to 16,000 cycles per second or higher and its dynamic range extends from a sound pressure of 0.0002 dynes per sq. cm. at the threshold of hearing at 1000 cps. to at least 200 dynes per sq. cm. at the threshold of feeling. This very small pressure at the threshold of hearing produces a displacement of the ear drum that is of the order of 10^{-9} cm. This distance is less than one tenth of the diameter of a hydrogen molecule![4] The threshold of hearing and the threshold of feeling for a normal ear are shown in Fig. 2.

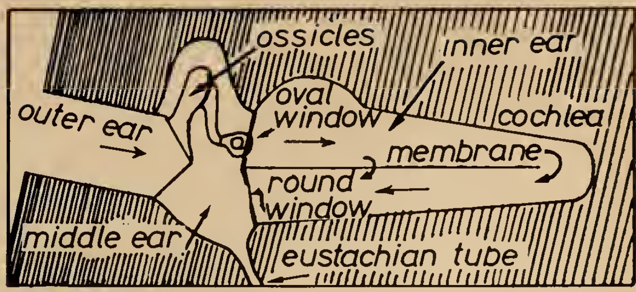
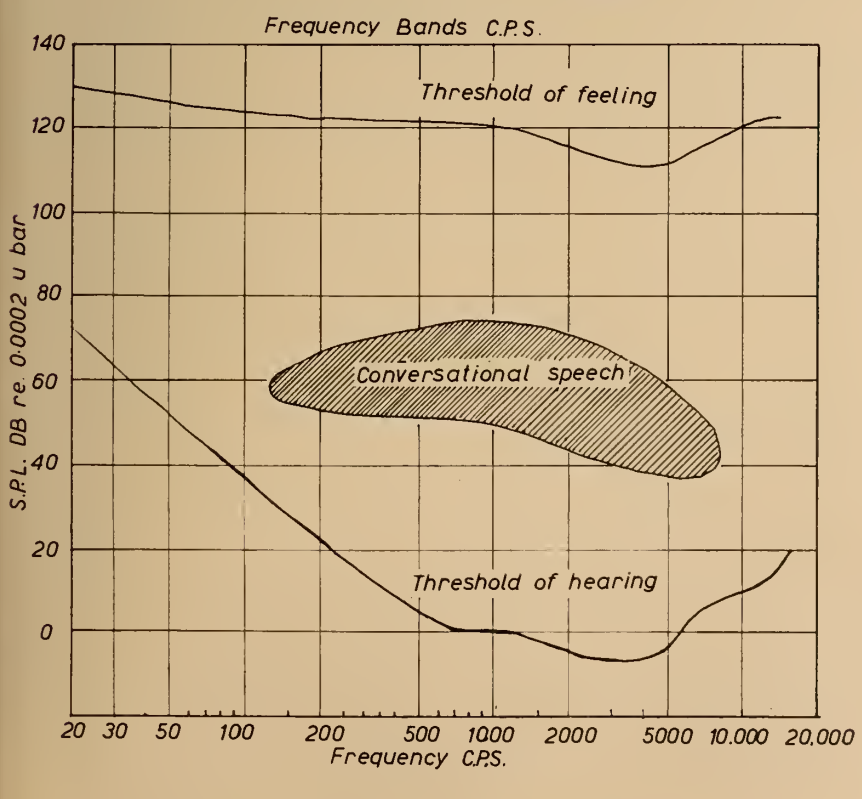


Fig. 1 Functional schematic diagram of the ear.

It will be noted that in Fig. 2 the "decibel" system is used to express the sound pressure level. Using this system, the sound pressure level in decibels or db is defined as $20 \log_{10}(P_1/P_o)$ db where P_1 is the sound pressure one wishes to express in db and P_o is the reference pressure. The reference pressure usually is 0.0002 dynes per sq. cm. which is the threshold of hearing at 1000 cps. If we take P_1 as equal to 200 dynes per sq. cm., then the corresponding sound pressure level is $20 \log_{10}(200/0.0002)$ db $=$ 120 db. This is the sound pressure level at the threshold of feeling at 1000 cps. re 0.0002 dynes per sq. cm. The reference pressure must always be stated. The decibel system is also used to express power levels in acoustics. Again, by definition, the power level in db is $10 \log_{10}(W_1/W_o)$ where W_1 is the power whose level one wishes to express in db and W_o is the reference power. W_o is taken at 10^{-13} watts. As an example, the average power level of the male voice speaking normally is 84 db re 10^{-13} watts. Thus $10 \log_{10}(W_1/10^{-13}) = 84$ or $W_1 = 25 \times 10^{-6}$ watts.

Fig. 2 Frequency dynamic range of the ear.



From the above, it is seen that due to the extreme sensitivity of the ear the amount of power involved in speech communication is exceedingly small. One man speaking at normal voice radiates 25 microwatts of acoustic energy. Thus, it would take one million men all talking at once to radiate the acoustical equivalent of the electric energy required to light a 25 watt lamp! Of course it would not work out quite this way because long before a million men could be assembled for the trial, the "cocktail party effect" would set in and everybody would be shouting! But perhaps the point has been made that ears are sensitive and even sounds which are very loud do not involve as much energy as one might suppose.

Fig. 2 represents the characteristic of the "normal" ear, but the normal ear is a young ear. There is a progressive reduction of hearing acuity with age in both men and women although the deterioration in men is somewhat greater at a given age. This loss of hearing acuity due to age is a permanent loss, but age is not the only cause of such loss. Damage to vital parts of the hearing apparatus will of course affect its normal functioning. However, our concern here is with the effects of noise and it has been established that sustained exposure to high intensity sound particularly at the middle and high frequency end of the spectrum can occasion such loss of hearing and that this loss may be permanent.

Noise being unwanted sound is, almost by definition, an annoyance, but the most specific occasion for annoyance due to noise is experienced when the noise prevents one from communicating with someone else either directly or by telephone. The phenomenon responsible for this speech interference is called masking. Speech sounds contain a great many frequency components extending upward to at least 10,000 cycles per second. Most of the energy in speech sounds is at the lower frequencies — up to 3000 cycles per second at least are essential for the intelligibility of speech. And there is very little acoustic power in these high frequency sounds. Thus if noise is present, the intensity of the wanted sound must be increased if it is to be heard above the unwanted sound. This effective raising of the threshold of hearing for the wanted sound by the unwanted sound is called the masking of the wanted sound. When we say that we cannot hear what the other person says due to the noise, we usually mean that while we hear his voice (low frequencies) we cannot understand what he says — because those higher frequency components which are essential for intelligibility have been masked by the noise. So we raise our voice; i.e., put more energy into the high frequency sounds to override the masking noise. The other person also raises his voice and we succeed in communicating. To have to shout to a colleague across the desk or to go to some other location to telephone or to spell out D for Donald, T for Tom and P for Peter, takes time and is annoying, but does enable us to convey meaning in spite of the masking effect of the noise.

Table I

Speech Interference Levels (S.I.L.)—Average Male Voice

Distance Feet	*Voice Level*			
	Normal	*Raised*	*Very Loud*	*Shouting*
0.5	71 db	77 db	83 db	89 db
1	65	71	77	83
2	59	65	71	77
3	55	61	67	73
4	53	59	65	71
5	51	57	63	69
6	49	55	61	67
12	43	49	55	61

Summary

1) The human hearing apparatus in its normal condition is extremely sensitive and responds over a wide range of frequency and sound pressure.
2) Its sensitivity decreases with age and may be seriously impaired by sustained exposure to high level noise.
3) For speech to be intelligible, frequency components up to at least 3000 cps. must be clearly heard. The phenomenon of masking results in noise causing interference with speech communication.

The Role of the Engineer

So far I have been considering the phenomena and effects of noise. A good deal of this is of course familiar to you. What you would like to know now is what you as an engineer can do about the problem.

Noise is just another engineering problem and the approach to this one is the usual approach — get at the facts. When people — any people, complain about noise, they should be taken seriously. Their reaction is qualitative and subjective, but it corresponds in some measure to the quantitative and objective situation. What are the facts? What sound pressure levels at what frequencies are actually present in the area where the people concerned are working? Until these facts are known, nothing can be done. When we know them, we can compare them with established criteria regarding hearing damage risk and speech interference.

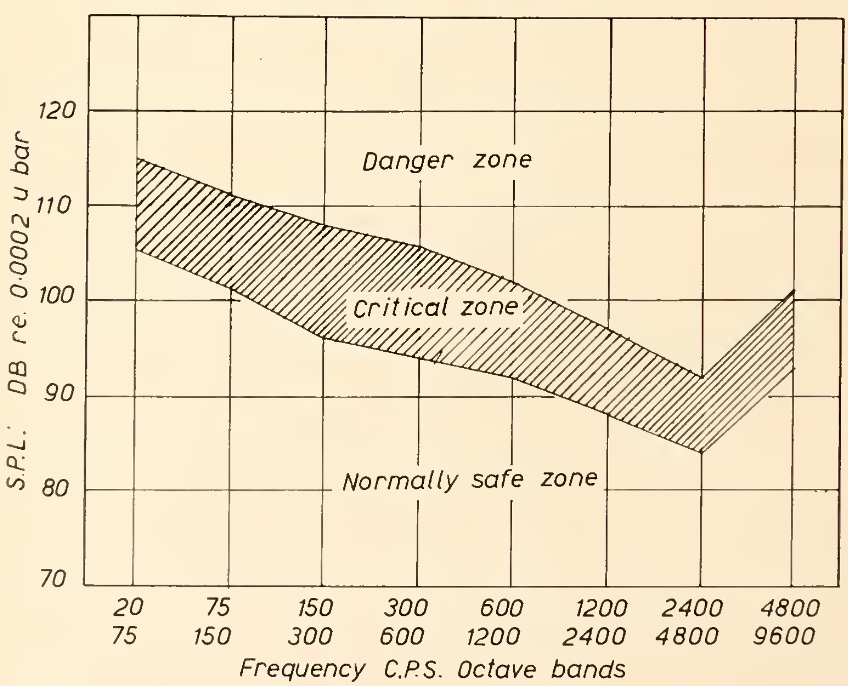
In Fig. 3, "Tentative Hearing Risk Criteria"[5] are shown in the form of a graph. Ears vary a great deal in sensitivity and sound pressure levels which may damage some ears in a short time of exposure may leave other ears unaffected. The safe thing to do is to keep the levels below the critical zone. If measurements indicate for example the sound pressure level in the 300 to 600 cps. band is 100 db, then to avoid hearing damage to those working in that area, the level must be reduced to 94 db or lower.

In Table I are shown Speech Interference Levels in decibels (re 0.0002 dynes/cm²) which barely permit reliable word intelligibility at the distances and voice levels indicated.[4] It is assumed that there are no reflecting surfaces to aid the direct speech.

It will be noted that the voice levels are 6 db apart and that each doubling of distance requires a reduction of 6 db in the permissible S.I.L.

The S.I.L. is defined as the arithmetic average of the Sound Pressure Levels (SPL re 0.0002 dynes/cm²) in the 600-1200, 1200-2400 and 2400-4800 cps bands. Thus for example, if the S.I.L. is 49 db, two people may converse in a normal voice at 6 ft. If they are 12 ft apart, they will be

Fig. 3 Tentative hearing risk criteria.



able to converse equally well if they raise their voices 6 db. However, if they are to converse at normal voice level when 12 ft apart, the S.I.L. must be reduced to 43 db.

Beranek[6] has given noise criteria for offices based upon extensive experience as a consultant on office noise problems. In the table and curves which follow (Fig. 4) NC means Noise Criterion and the NC number refers to the speech interference level. Thus NC-40 means an S.I.L. of 40 db.

These noise criteria are based on today's acceptable speech interference levels. No doubt they will be altered as our knowledge of these matters is extended. Similarly with the hearing damage risk criteria. Hardy's[5] paper referred to was published seven years ago. Glorig,[7] writing five years later, suggests the following:

"If the sound energy of the noise is distributed more or less evenly throughout the eight octave bands and if a person is to be exposed to this noise regularly for many hours a day, five days a week, for many years, then, if the noise level in either of the 300-600 cps band or the 600-1200 cps band is 85 db, the initiation of noise exposure controls and tests of hearing is advisable. The more the octave band level exceeds 85 db, the more urgent is the need for hearing conservation."

However, in spite of the fact that these criteria are likely to change, it is clear that enough data is available to make a start. Using these data as criteria and comparing them with the measured data in the area under study, the amount of noise reduction required may be readily seen.

To solve problems in any branch of engineering, one must know a certain amount of basic theory. The basic theory of acoustics is not especially difficult, but it must be mastered if one is to handle noise problems intelligently and with a minimum of expenditure. In the bibliography at the end of this paper, reference is made to some suitable textual material.

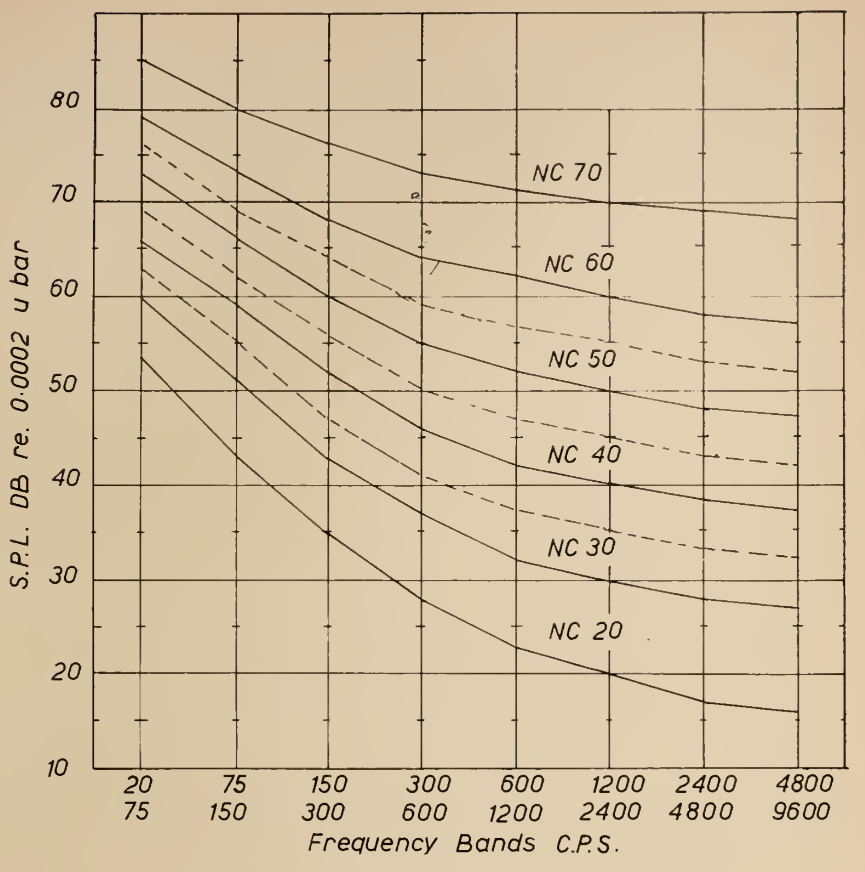


Fig. 4 N. C. curves.

Summary

1) As with any other engineering problem, the engineer must in this case obtain quantitative, objective data about the noise levels in the space he is concerned with;
2) Criteria are available concerning damage risk and speech interference levels which enable the engineer to decide what noise reduction is required in a given area to achieve acceptable conditions;
3) The intelligent application of acoustic theory can lead to a satisfactory solution of many of our noise problems.

Measurements

To obtain quantitative data on the noise at a given location, one must make measurements and the essential equipment for this purpose is a Sound Level Meter and an Octave Band Analyser.

With the Sound Level Meter one determines the over-all sound pressure level at all working locations where it is difficult for two persons with normal hearing to converse at arm's distance.[8]

The Sound Level Meter measures only over-all sound levels. For a more complete description of the sound, measurements involving frequency are also necessary. This is the function of the Octave-Band Analyser. Neither hearing damage risk nor speech interference levels can be determined by a single-number, over-all level. One must also know how the sound energy is distributed over the frequency spectrum.

The Sound Level Meter consists of a microphone, an amplifier, an attenuator and an output meter, all housed in a small portable box. The device is powered by batteries or may be adapted for use with the 110V, 60 cps supply. This instrument which has characteristics specified by the American Standard Association gives the Sound Pressure Level in db re 0.0002 dynes/cm^2. The Octave Band Analyser is used in conjunction with the Sound Level Meter and taken together one obtains the sound pressure level in each of eight octave bands extending from 37.5 cps to 9600 cps.

The Sound Level Meter costs about $350 and the Octave Band Analyser costs about $550. A vibration pickup may be added for $100 making a grand total of $1000 for all of the essential equipment.

Acoustical measurements are something of a science and something of an art still. The available instrumentation is adequate but must be used with understanding and the results interpreted with care. One cannot in a paper such as this go into the details of what to do and what not.

Instrument manufacturers supply very good manuals with their meters and much will be found in the literature to guide the novice. In a good many situations high accuracy in measurement is not essential in a preliminary survey and a preliminary survey may be sufficient to indicate the magnitude of the problem on hand. By the time management has been persuaded to take the matter seriously, the engineer who has been assigned to "clean up the problem" can have acquired considerable experience in making the necessary measurements.

Summary

1) The essential equipment for making noise measurements is a Sound Level Meter and an Octave Band Analyser.
2) This equipment will cost about $900 plus customs duty.
3) With this equipment and a clear grasp of basic acoustic theory, most noise problems can be dealt with fairly adequately.

Treatment

The first problem is always to get at the facts about the actual noise levels that exist and their frequency distribution.

The second problem, assuming that these levels indicate that some reduction is in order, is to isolate the source of the noise — find out what is vibrating. The ideal solution to every noise problem is, having discovered the source, to eliminate the noise at the source. If the source is your neighbour's radio or T.V. or 2-year-old child, the solution may call for more knowledge of psychology than of acoustics. If the source is a machine, some part of which is vibrating, partial redesign of the machine or the stiffening of some structural member may kill the vibration or move it to a part of the frequency spectrum where it is less bothersome. The first step is to locate the source. If the noise cannot be eliminated at the source, it may be possible to modify its environment.

At this point some knowledge of room acoustics is a good thing. A noise source radiates sound in all directions and these sound waves travel out at about 1130 ft. per second toward the boundaries of the room. Some of the sound energy is absorbed at the room surfaces and the remainder is reflected. Depending on the size of the enclosure, there may be many reflections in a second and before very long a diffuse sound field is built up in the room. This diffuse sound field is called the reverberant field. It is always much weaker than the direct sound near the source. The operator of the machine which produces the noise is in the direct sound field; the other people in the room are in the reverberant sound field. The more absorbing material there is on the room surfaces, the weaker will be the reverberant field and hence the less will the other people in the room be affected by the noise. But increasing the room absorption will not help the operator of the machine — his machine makes the noise. Thus to eliminate the noise at the source is to help everyone; to treat the room only is to help the many but not the machine operator. The first effort should therefore be to work on the machine.

If the machine cannot be altered to reduce the noise, perhaps it can be moved or enclosed. Sometimes vibration in a machine is transmitted through its foundation to structural members of the building and so appears on all floors. Resilient mounts for the machine may be the answer. The paths by which noise is being transmitted should be examined. A ventilation duct outlet in one room may be delivering air and picking up noise which is then delivered through another duct opening into another room. The walls between the machine room and an office may have sufficient transmission loss to reduce the outside noise to a suitable level, but there may be holes in the wall to let pipes through. The transmission loss through an opening is zero.

There is no single formula which will give the answer in all cases. Such formulae as there are must be used with understanding and judgment and success in handling a noise problem means reduction of the noise to acceptable levels at reasonable cost. But instrumentation is available to make the necessary measurements and useful theory and criteria have been developed over the past 25 years to handle these problems satisfactorily. What is needed now is the will to do something about noise.

Summary

1) First, determine by measurement the noise levels and the frequency distribution on an octave band basis.
2) Isolate the source of the noise, by modification of the machine, moving the machine, building an enclosure around the machine.
3) The operator of the machine is in the direct field and can only be helped if the noise is reduced at the source.
4) Other people in the room are in the reverberant field and can be helped by the use of sound absorbing material in the room.
5 All the paths by which sound is

Table II

Recommended Noise Criteria for Offices

NC Curve of Fig. 4	*Communication Environment*	*Typical Application*
NC-20 to NC-30	Very quiet office. Telephone use satisfactory. Suitable for large conferences.	Executive office and conference room for 50 people.
NC-30 to NC-35	"Quiet" office. Satisfactory for conference at 15' table. Normal voice 10-30 ft. Telephone use satisfactory.	Private or Semi-private office. Reception room. Small conference room for 20 people.
NC-35 to NC-40	Satisfactory for conferences at 6-8 ft. table. Telephone use satisfactory. Normal voice 6-12 ft.	Medium-sized offices and industrial business offices.
NC-40 to NC-50	Satisfactory for conferences at 4 to 5 ft. table. Telephone use slightly difficult; normal voice 3-6 ft., raised voice 6-12 ft.	Large engineering offices, drafting rooms, etc.
NC-50 to NC-55	Unsatisfactory for conferences of more than 2-3 people. Telephone use slightly difficult; normal voice 1-2 ft.; raised voice 3-6 ft.	Secretarial areas (typing), accounting areas (business machines), etc.
Above NC-55	Very noisy. Telephone use difficult. Unsatisfactory for offices.	Not recommended for any type of office.

NOTE: Noise measurements made for the purpose of judging the satisfactoriness of the noise in an office by comparison with these criteria should be performed with the office in normal operation, but with no one talking at the particular desk or conference table where the measurement is being made.

transmitted from source to receiver must be examined and blocked.

6) Remedial measures are always possible once the decision has been taken to clean up the noise situation.

The Future of the Noise Problem

Not so many years ago, refrigerators and automobiles were very noisy. They are not noisy now because the purchasers of these devices preferred to have them quiet and in a highly competitive market, whoever built the quietest machines sold them. The pressure is now on outboard motor manufacturers, on the manufacturers of all kinds of tools operated by compressed air; on the manufacturers of large power transformers. Not long ago a Russian jet airliner was not allowed to land at New York's Idlewild Airfield because its noise levels were too high.

A corresponding French machine, the "Caravelle", was granted permission to land because it had met the noise limit requirements of the air port authorities. And you may have heard that in Paris taxi drivers are no longer permitted to blow their horns with such gay abandon.

The writing is on the wall. Between customer preference and civic ordinance, the makers of noisy machines, devices and appliances must now be concerned with decibels as well as with horse power, efficiency and cost. This concern will become acute when the purchasing agents for industrial firms begin to add to their machine specifications, the maximum noise levels they are prepared to accept!

But the desire for peace and quiet is not the only force at work in this situation. Certainly the major immediate reason for the widespread attention given to noise problems in the United States is the increasing number of claims for compensation awards on the grounds of deafness incurred while working in a noisy environment. Only recently has Workers Compensation legislation in that country been extended to cover this disability. Some day some union negotiator will lay it on the line that certain specified maximum noise levels must be written into the contract. That will be a bad day for the employer but a happy one for everyone else.

The problem of traffic noise has not been mentioned here although there has been incidental reference to efforts to control aircraft noise in and about airports.

Something can be done about noise and the sooner engineers become noise conscious and begin to work on the problem, the better. The reduction of noise to acceptable levels in the nation's industrial plants and offices is going to cost a lot of money. It may cost a good deal in your own plant, but it will cost a good deal less and a more effective job will be done if those who tackle it are supplied with adequate measuring equipment and know what they are about. The cleaning up of the noise problem is also going to save a good deal of money — in the long run. We are told that public relations, like charity, begins at home. Nothing, one would imagine, could do more for workers' morale than a serious, all-out effort to reduce factory and office noise. A good many precious ears will be saved from partial or total destruction; there will be greater efficiency because of easier communication; less strain on everyone. And perhaps machines might even last longer if they didn't shake so much.

I have, of course, given you an over-simplified picture of what is involved in this noise problem. Some of you know this; the others will find it out when they try to do something about it. However, one cannot give a course in acoustics or apply acoustic theory to a multiplicity of noise problems in a short paper. If I have stimulated your interest in the matter, that will do for a start.

Summary

1) Machine manufacturers will build quieter machines if we demand them.
2) Loss of hearing due to long time exposure to high noise levels may be a responsibility of the employer and call for worker compensation.
3) Unions may justifiably demand the elimination of high noise levels as an industrial hazard.
4) Noise is definitely an engineering problem and the sooner engineers accept it as such, the better.
5) A noise reduction campaign will cost money, but in the long run may well save money also.

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No.'s 1, 2, 6 and 7 are most important.

DISCUSSION

of Technical Papers and Other Articles

SOME CONSIDERATIONS IN STEAM POWER PLANT DESIGN

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The Engineering Journal, 1959, October, p. 63.

Discussion on the paper, "A Gas Turbine Power Plant for Locomotives" followed Professor Christie's paper in our October issue, and we offer sincere apologies to our readers and to the authors of both papers for any confusion this may have caused.

Author's Reply

This brief paper brought out a surprising amount of constructive discussion. This indicates that Canadian engineers are keenly interested in, and quite aware of, the problems of modern steam plant construction and operation.

Canadian utilities are growing rapidly and in all probability will continue to do so for many years. Some will triple and others quadruple in size during the next fifteen years which is less than half the expected life of the steam units that will be added. Under such conditions small generating units to fit today's situation, become uneconomic with rapidly growing loads particularly in view of interconnections and pool formations. Hence foresight and judgment rather than probability calculations must govern the choice of new plant. Such considerations point to large unit sizes and the more advanced steam conditions.

Hydro electric power must, in the future, take a secondary place in most Canadian power systems to steam and atomic generated power. Then hydro plants with water storage, will be modified to serve on shift operation to carry peak loads and to serve as emergency stand-by, leaving base loads to the steam and atomic energy stations. This will increase the Kilowatt-hour total output of the steam turbine generators during their useful life and thereby justify the large sizes of such units and their high steam operating conditions.

Mr. Holdup presents certain considerations in plant design based upon operating experiences with shift operation of large plants. These are essentially sound and acceptable.

Messrs. Carruthers, Stanley and Mitchell have submitted comments also based upon operating experiences and such should be kept in mind in the design of new plants.

Messrs. Foster, Bernhardt and others discuss the control of power plants. The control room will be a central feature of all new plants. It is going through a developmental period and its functions will be better understood in the future. Its equipment will be simplified and made more reliable and safe. Complete automatic control of the steam plant and the integration of its performance data can be expected although some problems remain to be solved. Some instruments such as the TV sets used on boilers need to be greatly improved.

Mr. Dryer had much to do with the establishment of the present Preferred Standards for steam turbines and other standards. He urges further standards for large units. No agreement has been reached on such standards.

Dr. Robb has reviewed the historical development of steam plants in Canada.

The suggestion to lower flue gas temperatures drew extended comments. Such lowering introduces design and operating problems but the possible gains warrant the solving of these. Obviously condensation, corrosion and dust collection on any cooling equipment in the flue gases must be considered. Preheating of the cold air to the air heater is required in cold weather. It has been the experience that steam preheaters using bled steam have given much trouble in northern plants, from freezing, particularly with shift operation or varying loads. It has been proposed to use cast iron gilled economizers in the flue gases beyond the induced draft fan and to circulate through these an anti-freeze fluid which will lower the flue gas temperature and transfer the recovered heat to tempering coils in the cold air inlet of the air preheater. Corrosion troubles in chimneys due to low flue gas temperatures can be prevented by acid-proofing the lining.

Mr. Holdup comments on fly ash. The quantities of this ash will increase and it is highly desirable that economic uses for such ash should be developed.

Other considerations were presented by discussors with which one is in general agreement. These will aid in the design of still better steam plants in Canada.

SHOCK HAZARDS OF ELECTRIC CURRENTS

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The Engineering Journal, November, 1959, p. 50

Author's Reply

Mr. Campling felt that I had created an impression that the proposed residential voltage increase was a complete change from 120 volts-to-ground to 240 volts-to-ground. The criticism is well made. In answer, first I would say that I did refer to H. H. Watson's paper twice in my talk, and on the first occasion I stated that "limited use of the higher voltage" was considered. On the second occasion (see concluding paragraph) I enlarged on this by giving in full one of H. H. Watson's conclusions — "Potentials of 240 volts-to-ground should be used only for permanently wired fixed appliances." Second, I would say that I deliberately emphasized the 240 volt-to-ground hazard as being a general hazard, in contrast to the above restricted hazard for the following two reasons:

(a) It is difficult to see how all concerned can be restrained to the "restricted use" formula, once the door is opened. A paper by Anderson, Hutchinson and Pearson ("Higher Secondary Voltages for Residences" Feb. 1959 issue of Trans. AIEE) makes this perfectly clear. The authors say "Although it may be necessary initially to make provision for supply of 120 volts, the maximum economies of higher voltage secondaries cannot be realized until 240 volts is the universally accepted utilization voltage". Furthermore, in this paper and the Discussion arising from it, it was strongly indicated that it was doubtful if there was any economic gain unless (or even if?) the increase was general. The discussion also showed that several of those commenting feel sure that the possibility of increased hazard to life cannot be avoided and that the small economic gain is not worth it.

(b) While it is not possible to give clear-cut comparisons between British (or European) and North American experience, I would agree with Mr. Flinn that Americans are more inclined to do-it-yourself than the British. Hence the ultimate use of 240 volts-to-ground in America may be a greater hazard than in Britain. Education of the public could only partially compensate. Wills Maclachlan[1], in a paper to the AIEE in 1951 gives a British table showing some figures for electric shock in factories. Unfortunately it does not break down the voltages in the 0-250 volts group. But it is to be noted that resuscitation was twice as successful in this group as in the next group (250-650 volts). One can make the reasonable assumption that, in the range 0-125 volts, resuscitation under similar (factory) conditions would be even more successful than in the 125-250 volt range.

Mr. Flinn refers to the comparison, between different voltages, of the percent of successful resuscitations of "apparently dead" electric shock victims. It is fairly well established (see W. Maclachlan[1]) that for voltages between 250 volts and 5000 volts, successful resuscitation is most difficult. At the high voltage end, it is speculated that increased success is because (a) the victim is thrown clear and hence the current is of short duration (b) the current causes heart seizure and not ventricular fibrillation. Additional reasons may be the high voltage may puncture the skin causing a low resistance path thus giving a current surge above the fibrillation level; the workman involved is not alone and hence rescue is begun rapidly; and his rescuers know what to do. At the low voltage end, it is speculated that increased success is because the current has been too weak to cause fibrillation, but has caused "only" severe shock, inability to breathe, and loss of consciousness. In a sense, the low voltage end is more serious than the high voltage end because: electrical contact occurs more frequently and often under low body resistance conditions, contact is more prolonged, rescuers are less capable, children (who require less current to succumb) form a larger percentage of the victims.

The current required for heart defibrillation is a function of the size of the heart. Experiments[2] with dogs have shown that the resistance of the dog's heart is around 50 ohms and that 60 cycle defibrillating currents between 1 and 3 amperes have been required for a pulse duration of about 1/10 second. I believe human hearts are in the same range of size as the hearts of these dogs. Defibrillators and electrocardiographs certainly have an important place in saving victims of shock, but I feel it is absolutely essential to maintain a high standard of training in rescue work and manual artificial respiration. Especially important is the tradition of not losing a second in commencing resuscitation and in NOT moving the victim, say to a location where there is special equipment, in the meanwhile administering no artificial respiration. Mr. W. Maclachlan (in discussion from the floor) doubted that heart defibrillators would become standard equipment for line crews.

Mr. Maclachlan also mentioned that in one large Canadian Utility, artificial respiration was successful in 100% of the cases where voltages were from 0-750 volts. This is indeed an enviable record. He stated that fibrillation may not have been present in these cases, or may have passed off. He suggested that perhaps fibrillation does pass off after a time and if artificial respiration is continued to "success" or to "rigor mortis", one may, contrary to popular belief, therefore be able to resuscitate a victim of fibrillation. Dr. Ballard pointed out that loss of blood (and oxygen) to the brain during the period of fibrillation is considered to be very serious and even fatal if lasting for more than a minute or so. From all that I have read, I have assumed it to be pretty well proven that recovery from fibrillation is extremely doubtful unless the heart is given some form of defibrillating treatment; Mr. Maclachlan's remarks are therefore, to me, very much appreciated, as he is undoubtedly an authority on the subject.

The increasing use of electrical appliances out-of-doors is going to lead to an increase of deaths from electric shock. Two such cases have come to my attention recently. One involved the use of an electric sander on a car fender. A young girl in her bare feet (it had been raining) was electrocuted upon contact with a defective cord. And in today's paper there is a report of a woman being electrocuted when she stepped in a puddle while using her electric lawn mower. I do not like to contemplate the additional effect on this type of death of increasing the voltage to ground. Nor should we forget the utility men who will be exposed, rain or shine, to 240/480 secondary circuits regardless of the voltage in residences, if the proposed increase is accepted. I agree with Mr. Maclachlan who feels there is still need for study of the problem of electric shock and how to overcome it.

1. "Electric Shock" by W. Maclachlan, Ontario. AIEE Misc. Paper 51-281, May, 1951.
2. "Electric Countershock Treatment of Ventricular Fibrillation" by J. A. Hopps, N.R.C. No. 3015, June, 1953.

SILVER FALLS GENERATING STATION

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The Hydro Electric Power Commission of Ontario.
The Engineering Journal, October, 1959, p. 108.

Reply by Authors

The authors wish to thank Mr. Patterson for his complimentary remarks. Mr. Patterson has rightly pointed out that the method of shaft raising employed at Silver Falls has been successfully used in countries other than Sweden and the authors are anxious to dispell any misapprehension that the system was unique. There was full utilization of any published data or, the subject, particularly the paper *Novel Shaft Boring Method* presented by R. S. Henderson and published in the Institution of Civil Engineers Proceedings Vol. 6

April 1957. The authors also wish to record their indebtedness to Mr. Belanger of Atlas Copco of Canada Ltd. who provided them with invaluable data and introduced them to Swedish engineers who had been actively engaged in shaft raising operations for the Swedish State Power Board projects. In answer to Mr. Koring's request for further information on the shaft raising drill cage it should be understood that its design is largely dependent on the amount of use it will be subjected to and the competence of the rock.

There were two such cages used at Silver Falls G.S. which were simpler and cheaper to construct that those used either at the Scottish or Swedish projects where the usage factor was much higher. The first cage, which is depicted in a sketch accompanying the paper was octagonal and had a sectional cone shaped steel roof which acted as a shield while travelling to and scaling the face. Since it was partially destroyed at the completion of the surge shaft raise it was decided to build a new one. This cage was circular in plan, had closer spaced verticular frame members which acted as rubbing strips, a flattened dome shaped roof with heavy screen cloth as a shield and an improved water and air supply system. The roof was a fixture incorporating an access hatch and six telescopic arms which were used to steady the cage and support loose planking. The original method of pinning the cage to the walls of the raise was discarded in favour of pivoted spuds which jammed into the rock crevices of the raise walls.

The normal mine system of communications between the miners and hoist operator was used plus a field telephone for communication with their helper at the bottom of the raise. Mr. Koring can be assured that the hazards of rock tunnelling and shaft raising were foremost in the minds of those responsible for the operations at Silver Falls G.S. The Safety Officer, superintendents, engineers, foreman and the miners collectively established the procedures and type of equipment to be employed. Having instructed each man on his duties we made practice runs until the superintendent was satisfied that the equipment was functioning correctly and operational hazards were reduced to a minimum. For the shafts, each miner was instructed individually neither to jeopardize safety for expediency nor to deviate from the adopted procedures. The safety program at Silver Falls G.S. was developed from data we had accrued from the tunnel driving operations at Aguasabon G.S. and the East Delaware Aqueduct, which was additional to the valuable guidance received from Canadian Industries Ltd. and the Departments of Mines and Labour. In this regard it is a pleasure to record that there were no fatal accidents during either the excavation or concrete lining of the Silver Falls tunnel and shafts.

Mr. Koring asks whether we would advocate using a churn drill or a diamond drill for a pilot hole. Unfortunately our experience is limited to one application of each and neither proved conclusively that one is markedly superior. However, as Mr. Patterson has pointed out, churn drills have been used successfully down to greater depths elsewhere and in the authors' experience the 9 in. diam. hole slightly off line is preferable to a dead plumb 4 in. diam. hole. We would therefore advocate using a churn drill unless time was of the essence. It is possible that a pneumatic drill on the lines of the 'Mole' drill might be an answer to the problem.

Diamond drilling whether for exploratory holes or for a pilot hole is relatively expensive and should be reserved for situations where a percussion drill is unsuitable or a core is required. At Silver Falls the exploratory holes drilled from the surface during the early stages of the job to establish the tunnel alignment were very costly since they had to penetrate up to 400 ft. of overburden.

These were subsequently augmented during the tunnel drive using a pattern of overlapping horizontal and angle holes which provided more detailed information of the rock formation and cover and anticipated water inflow ahead of the face. Including sampling and testing these holes cost $5.00 per lin. ft. and in no way retarded the tunnel drive.

This probing ahead eliminated most of the inherent risk of the tunnel drive being halted or retarded to overcome adverse rock or water conditions in the 'Depression' area.

In the authors' opinion, the money was well spent and must be considered as an insurance policy, to which most commercial undertakings would subscribe.

Mr. Koring asks for more information on the scheduling and economic aspects of the site preparation construction facilities and tunnel operations.

Originally it was hoped to commence tunnelling operations two months before the actual starting date. A setback was caused by an accumulation of delays in obtaining the specialized equipment and the more extensive nature of the preliminary excavation to establish the portal face. Less expensive and possibly more readily obtainable equipment had been considered, but subsequent events proved that the choice was well founded.

Silver Falls G.S. was placed in service on the date originally specified by the Commissions Engineering Division, any slower less costly method of tunnel driving would have prevented this. Almost half the specialized tunnelling equipment has been sold to private contractors at going prices.

The choice of tunnel driving methods and equipment is inevitably contraversial whenever more than one system can be utilized and the authors would not attempt to dogmatize on such an issue.

The construction roads and facilities were designed to meet the job requirements and standards of accommodation established by the Commission. In some respects they might be considered more extensive than some private companies would employ under the same conditions. Certain factors such as standards of employee accommodation and recreational facilties effect management relationships with the men, the unions, the industry and the public, and the costs incurred must be judged accordingly. The Commission employs engineers and technicians whose main function is to reduce expenditures and improve the standards of their construction camps.

The relationship between the unions and management at the site was excellent considering that the basic philosophy of the construction trade unions runs counter to the establishment of incentive pay. There were no work stoppages and there was a mutual respect by both parties for each others aims and ambitions. Both unions and management were on common ground when discussing the safety aspects of the job and this in itself provided the keystone to their good relationship.

Mr. Koring asks why the average powder factor was 5.1 pounds per cubic yard. During the early stages of the tunnel excavation the powder factor was adjusted both ways in an attempt to establish an optimum which would produce the minimum bootleg and best fragmentation for the mucking machine. After several abortive attempts to reduce the powder factor and rearrange the drill hole pattern, a standard pattern of 72 holes and a powder factor of 5 was established by the superintendent and shift bosses which produced an average advance of 15 ft. per 16 ft. round. No doubt a lower powder factor could have been used for a shorter round.

The overbreak varied considerably according to the rock formation and the experience of the miners and supervisors. Initially the overbreak was excessive until the diameter of the drill hole circle was established and the miners controlled the flair on the holes. During this period the average overbreak was about 18%. After the tunnel had advanced 2,000 ft. the overbreak was nil due to the extremely competent granite formation and this continued until we encountered a blocky formation near the halfway mark. This condition reoccurred for most of the remaining 5,000 ft. of tunnel and in consequence of this the overbreak averaged about 10% for the entire tunnel. This was 2% under the overbreak allowance in the engineers specifications.

Roof bolts were installed to support exposed slip planes and overhanging blocks of rock which the shift bosses and superintendent considered as unsafe. Their concentration varied considerably, but in the worst sections were spaced at about 4 ft. centres and used in conjunction with spreader plates and wire mesh.

The main power supply to the tunnel was 2,300 volts and fed through a 2/0 No. 10 wire armoured cable from three single phase 333 kva. 7200/2300 v transformers. Step-down banks of 3-25 kva. single phase 2300/550 v. Askarel filled transformers were located at each fan station which were at 2200 ft. intervals and 1-5 kva. 2300/110 3 phase transformer were located at 1100 ft. intervals which fed into 1/0 cabfire lighting cables, 550 ft. in each direction. The electric mucking machine was powered through a 1500 ft. No. 14 type W Rinj cable which was supplied by 3-37.5 kva. single phase 2300/550 v. Askarel filled transformers. This bank of transformers was moved into successive transformer caves located at 1100 ft. intervals as the tunnel advanced, the mucking machine never being less than 400 ft. nor more than 1500 ft. ahead of the transformers.

A 5 kva. 3 phase 550/110 skid mounted transformer provided temporary lighting in the vicinity of the working face for those sections which could not be serviced by the permanent system until the next station was established.

A continuous grounding bus of 4/0 bare copper conductor had a grid resistance of about 3 Ohms. The installation was designed for a ±5% maximum voltage variation.

Mr. Koring asks for clarification on the extent of the widening at the passing tracks and the facilities provided at the servicing bays. The passing tracks were located at 7 ft. centres providing 6 in. clearance between the widest parts of the track equipment. The slashing for the passing tracks was carried out without effecting the tunnel progress and consisted of widening 1 ft. at the spring line and forming a vertically sided horseshoe cross section. The servicing bay was slashed out a further 6 ft. to accommodate the flaps of the drill jumbo when fully extended. Included with the servicing equipment was a hand operated hoist attached to a radius arm pressure greasing and compressed air cleaning equipment and electric and gas welding sets.

The 15,000 c.f.m. ventilation system was designed to meet the Department of Mines regulations governing the operation of diesel engines underground, which was about 40% more capacity than would be required to meet the 50 c.f.m. per sq. ft. of tunnel face regulation. Under favourable conditions the worst of the smoke and fumes were cleared in 15 minutes and by using compressed air and hosing down the muck pile the fumes were cleared to a safe level within 30 minutes.

In replying to Mr. Patterson's request for information on the conditions encountered, the authors appreciate that this was an obvious omission on their part. Perhaps one reason for it was that, for the most part, the tunnel and shafts were excavated in competent granite or paragneiss which required only occasional roof bolts for minor slips and blocky ground. The worst section occurred at the 2/3 point of the tunnel where mud seams up to 2 in. wide, major slip planes dipping at 45° to the west and highly fractured paragneiss was encountered. Although steel arch ribs and plates were available at the site it was decided that a heavy concentration of 12, 10 and 8 ft. long roof bolts with 6 ft. long steel spreaders and No. 12 wire mesh would meet the condition with the least delay to the tunnel advance. The section was approximately 200 ft. long and caused an accumulative delay of 3 days. The entire area was gunited to prevent any further loosening of the rock, since the mesh prohibited regular scaling of the section. We had no further trouble in this area.

The rock beyond this point was much 'blockier' than we had previously encountered but by this time the supervisors and miners were well experienced in coping with the less favourable conditions and the 45 ft. per day progress was maintained to the end.

The water inflow as might be expected was greatest in the rock depression area and towards the intake. One of the miners drilled into a water pocket in this area which blew out the steel and sent the man sprawling across the upper deck of the jumbo. While it caused a momentary panic amongst the crew, no one was hurt and the jet of water subsided shortly afterwards, allowing the crew to complete the round on schedule. The total water inflow never exceeded the 250 i.g.p.m. capacity of the 3 in. submersible pumps which were used to repump the water into the discharge line from the sludge tanks. The level grade of the tunnel created a drainage problem during the invert clean up and placed a heavy demand on our supply of 3 in. and 1½ in. pumps, but we considered ourselves fortunate in not encountering a greater inflow than we did.

The rock formations in both shafts were very favourable, the intake more so than the surge shaft, where we took the precaution of guniting the walls to prevent loosening up of the exposed rock.

In conclusion the authors are indebted to Messrs. Koring and Patterson for bringing to their notice certain omissions in the paper and trust that the answers which have been given will shed further light on the excavation of the Silver Falls tunnel and shafts.

WHITEDOG FALLS AND CARIBOU FALLS GENERATING STATIONS

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The Hydro Electric Power Commission of Ontario.
The Engineering Journal, October, 1959, p. 73.

Author's reply

The author would like to thank those offering discussion for their interest and kind remarks. The replies to Mr. Travers' questions are as follows:

1. The support given the headworks by the powerhouse substructure

is minor and the headworks alone would probably be stable for all conditions excepting ice thrust. However, since the main pours of the powerhouse substructure were scheduled to be completed before raising the head water, the stability calculations were made to include the effect of the substructure.

2. As noted in the paper, care was taken to bring the concrete of the scroll case roof up evenly so as to prevent side thrust on the embedded parts of the turbine and to ensure that no setting had taken place so as to avoid "cold Joints" in the concrete. Admixtures were used to increase the setting time and to reduce the heat of hydration. The concrete was placed from dump trucks on a Bailey bridge above the form and was distributed through hoppers and elephant trunks. Under similar conditions, the same system would probably be used again, especially if the work occurred during winter when cold water and chilled aggregate would be available at no extra expense. Provision for draining possible cracks would probably be made by pouring the finished floor after the plant was in operation.

3. Smaller gates proved economical when included as part of the dewatering system as steel stop logs of this size were available for final closure from other plants. The large number of small gates also gave better river control.

4. An air bubbler system should reduce ice pressure on the headgates and racks during shut-down and reduce the trouble in opening sluice gates during cold weather. It is also hoped that an air bubble system will prove more economical than gate heaters.

5. No difficulties other than those noted occurred with the sand. The amount of air entraining agent was reduced and the trucking system of distribution proved so successful that no further examination of the sand was made.

In reply to Mr. R. E. Grout's question, the changeover to and from condense at Whitedog Falls is carried out remotely. In operation considerable adjustment of the timing relays controlling the inlet air valve has been necessary to prevent the generator from momentarily drawing large amounts of power from the system when going on condense. Also, it has been necessary to momentarily short out the probes which control the air shut-off because air from the turbo vents finds its way into the probe wells at the beginning of the condense cycle prematurely closing the valves.

Complete heating has been provided for all gates to be used until the air bubbler system has been installed and proved reliable. The author feels that even with the installation of the air bubbler system, gain heaters will be required.

In answer to Mr. Crowley's question regarding the economy of the earth wing dam at the Whitedog G.S. as compared with concrete, on a straight cost basis the earth was cheaper. However, if intangibles such as freedom in scheduling and earlier access from the right banks were taken into account, concrete might prove attractive. This would be dependent upon the overall schedule.

Due to the flow available when the Caribou headpond was being filled, and the good co-operation received, it was possible to fill the headpond and still maintain the required flow downstream. Most of the filling had been completed when the outlet to Tetu Lake was lowered. The water was allowed to drain off slowly without any control. This provided the downstream plants with some benefit which would have been difficult to measure and no consideration was given to compensation.

138 kv UNDERSEA CABLE ACROSS GEORGIA STRAIT

T. Ingledow, M.E.I.C., *President, B.C. Engineering Co. Ltd. Vanc. The Engineering Journal, October, 1959, p. 96.*

Mr. H. W. Smith's reply on behalf of Dr. T. Ingledow

I know Dr. Ingledow would like me to thank those who have submitted written discussion and to express his appreciation for the kind things which have been said in support of our work. Mr. Russell Potter's comments are particularly appreciated, as he was a member of the Public Utilties Commission at the time that regulatory body authorized the project as being in the public interest.

I would like to deal with Mr. Dale Farnham's comments, generally in the order in which they were presented.

The use of vibration resistant alloy E rather than a pure lead sheath, and the use of steel wire armour rather than an aluminum alloy are both a product of that conservative approach which, we feel, should accompany a novel installation. While ocean bottom conditions, as determined prior to installation, indicated that the cables would be supported throughout their length, changing currents could result in suspension of short lengths between humps of hard material, and under these circumstances abrasion and vibration might occur. The materials which have been questioned were chosen with this in mind. The more substantial mechanical characteristics of the cable afforded by the materials used have the incidental advantage of providing added protection against the arduous conditions of handling and laying. It is proposed to construct a one and a half mile causeway for car ferry purposes immediately to the north of the cable installation at Tsawwassen Beach, which could materially change bottom conditions in the vicinity. We were not aware of this possibility at the time the cable installation was made, but it is indicative of the sort of thing we have endeavoured to provide for.

With regard to the complete factory test of the cable, this, as Mr. Farnham points out, would have resulted in a large number of flexible joints being purposely provided. Three such joints were actually used—one being made necessary by a total interruption to factory power supply, and two due to equipment failures. Each such joint has an impulse withstand of 600 kv, rather than 675 kv for an unjointed cable. Further, we consider that such joints are regions of possible weakness, both electric and mechanical, since they are dependent on the human element. It was on these accounts that full factory testing was waived.

I believe Mr. Farnham may have quite unintentionally cast a slur on the Captain of the Monarch in his comments. The performances of both the Captain of the Ocean Layer and the Monarch on our installations were considered magnificent.

I agree with Mr. Farnham's comments with respect to complete field tests. We would like to make them too, but have never been able to get the installation out of service for a sufficient period.

With reference to the possibility of conversion to d-c installation at a later date, we regard the cables as suitable for this service, subject to the approval of navigational authorities.

Dealing with Mr. E. Bent's discussion, we have no indication that the reduction in armour losses due to the use of aluminum alloy rather than steel differs appreciably from the calculated reduction. Bonds between cable armour and lead sheath were made only at the cable terminations, the rubber sandwich being capable of withstanding the voltages which might be applied to it. The application of full gas pressure to the cable results in a measure of mechanical bonding between the lead sheath and bronze reinforcement, etc., which impairs flexibility and handling properties of the cable.

THE INTERCONNECTED POWER SYSTEMS OF NOVA SCOTIA AND NEW BRUNSWICK

G. D. Mader, P.Eng., *Chief Engineer*
Nova Scotia Power Commission, Halifax, N.S.
The Engineering Journal, October, 1959, p. 68.

Author's reply

The discussions presented are appreciated. We will attempt to clarify as briefly as possible some of the points raised.

In reply to Mr. McMath, several reference books and papers on probability analysis were utilized for this study, a list of which would be too lengthy for inclusion herein. Selecting one at random, AIEE Paper 57-692 entitled, "Use of Probability Methods in the Economics Justification of Interconnecting Facilities between Power Systems in South Texas", by A. Pat Jones and A. C. Mierow, may be of some help. Outage rates of 1% for steam and 0.5% for hydro units were chosen.

As regards steel vs. wood pole structures for 138 Kv. lines, the New Brunswick Electric Power Commission has experienced several failures on spar arm wood pole structures including pole twisting and shearing at guy wire pole bands. It was felt that steel towers would be somewhat more reliable under heavy loading conditions. Although first costs are about 15% higher, the annual costs are estimated to average about 1% less than for wood pole lines. In the Halifax area, the Nova Scotia Light & Power Co. Ltd. are using multiple circuit steel towers to minimize right-of-way costs where future circuits will be required.

The Nova Scotia Power Commission does have some wood pole 138 Kv. construction in the Maccan and Trenton areas. However, these lines do not have overhead ground wires since the isokeraunic level is considerably lower than that of New Brunswick.

Mr. Stanley's comments on the cost-size relationship are well taken and studies are currently in hand regarding the merits of larger generating units and utilizing the interconnection for firm power contracts in order to take advantage of the economics inherent in the location of such units. The peaking capacity of hydro plant will also be reviewed with an eye to obtaining optimum benefits for this combined hydro and thermal system.

The development or purchase of future sources of generation and the necessary associated transmission will be studied on a continuing as well as a fully co-operative basis with an eye not only to immediate but longer range requirements as well.

Again, we wish to thank the discussers for the interest shown and would certainly welcome any further comment from other interested parties.

TESTS OF HYDRAULIC TURBINES—AN APPRAISAL

J. J. Traill, M.E.I.C., *Consulting Hydraulic Engineer*
Toronto 18, Ontario.
The Engineering Journal, November, 1959, p. 66.

Author's reply

The author wishes to express his thanks to those who have participated in the discussion of this paper. It is very gratifying to have so many from among those eminent in hydraulic tests and investigations contribute their views to the subject under discussion.

Dr. Gibson outlines briefly the ideal conditions for the application of the Gibson Time-Pressure method but he has applied the method successfully in many instances far removed from these ideal conditions. Reference to one of these cases is made by Mr. Madill, viz. the tests at the Kemano G.S. where the net operating head was 2500 feet. The author, along with many others, has made tests by this method in plants with very short supply pipes and at low velocities, conditions far removed from the ideal indicated by Dr. Gibson. In these latter instances it can hardly be claimed that the same degree of accuracy can be expected as for tests where conditions are more favourable.

Mr. Johnson refers to the late Dr. Thoma's comments on errors in the Gibson method saying that it is "practically impossible to estimate the magnitude of the possible error in a dischage measurement by this method." This gives quite a different impression from that gained by reading Dr. Thoma's paper. Dr. Thoma made a theoretical investigation of the possible errors and arrived at the conclusion that these might amount, in the aggregate to about one per cent. In his analysis he dealt with the tests by the simple application of the method. In the differential application, that now generally used, certain of the errors would be reduced. An extended reference to this matter is made in reference No. 7 and further comments here would be a repetition of the information in that paper and the discussion thereon.

The Poiran Thermometric Method was included in this paper because few references to it have been made in publications on the North American Continent and because it is applicable to the measurement of turbine efficiency where other methods are not so conveniently applied. Dr. Gibson has made three inquiries regarding it. In other methods the useful work done by the turbine is measured. In addition to this the turbine has overcome its own bearing friction loss. In the Thermometric method all losses are measured without segregation. There is thus a slight discrepancy in the mechanical losses as dealt with in this and other methods of measurement. Dr. Gibson's second question asks what steps are taken to overcome possible changes in temperature (of the water) such as those caused by exposure of the penstock to the sun. The thermometric probes measure the temperature of the water close to the entrance to the scroll case (or the nozzle in the case of impulse turbines) thus automatically correcting for temperature changes in the penstock.

The limitation of the method to plants operating under heads of 100 meters and upwards is purely arbitrary. In various test codes, for other methods of testing, some limitation is usually named for acceptable conditions. This is so for tests by current meter, salt velocity and the Gibson method. In drafting the International Test Code some such limitation was considered necessary for the Thermometric method. The engineers of Electricite de France drew attention to a somewhat increased "scattering" of individual test points at low gate openings for tests at heads lower

(Continued on page 93)

Business and Institutional Buildings

NOT VERY long ago, business and institutional buildings might have been dismissed as a field of any importance for the application of control instrumentation on a large scale. As many engineers will realize, this is no longer the case.

The types of building considered here include office buildings, hotels, hospital, educational centres (schools, colleges, etc.), civic centres, government administration buildings, and so on. The principal applications for instruments in these buildings are in the fields of heating, ventilating, and communications. Educational establishments, to a varying degree, include laboratory facilities, and these may require instrumentation in connection with special laboratory services or for instructional purposes. These applications are outside the scope of the general field under consideration.

Applications of Instruments

Some general examples will indicate the scope for instruments in modern buildings of the types mentioned above.

Heating is essential for such buildings in Canada, and large boiler installations are commonplace. These installations require the usual combustion, temperature, flow, and other controls which have been discussed in an earlier article in this series (October 1959 issue). In addition, the control of temperature within a large building can be quite complex. For example, public rooms in an hotel, assembly halls or lecture rooms in a college, and public areas in an office building may be controlled by a zoning system to deal with varying rates of heat loss, different periods and degrees of occupancy (e.g., lecture rooms, which are only occupied at intervals), and other variables. On the other hand, local control may also be provided for temperatures in guest rooms, offices, laboratories.

Ventilating, and sometimes humidity control, is another field in which there may be a need for a complex control system. Here again, conditions in different zones of a large building may be controlled from one or more centres. The variables mentioned above may be taken into consideration in the overall control system.

As an example of a modern control installation, a large hotel has incorporated a supervisory data centre to control the operation of the heating and air conditioning systems. A graphic control panel shows a complete schematic layout of the fan systems, with dampers, heating and cooling coils, fan motors, etc. There are many different air-handling systems within the complete scheme, each of which, with its own variables, can be controlled centrally. An automatic data handling system scans and records temperatures at regular intervals, and warns of any departure from predetermined temperature conditions at various key centres. Such variations are also permanently recorded. Temperatures in public rooms are controlled locally by electronic thermostats, of which the setting can be varied from the central control panel. The flows of steam and water are also totalled on counters in the control centre.

Electrical services may include, in addition to lighting, power supply for operating elevators, pumps, compressors, fans, and so on. Quite large investment in standard metering and control equipment may be involved in a large building.

An interesting method of remote control of services uses the regular electrical distribution system as a means of communication, thus eliminating considerable lengths of cable necessary in conventional control systems. Selected frequencies are imposed on the electrical distribution system by an alternator; the output is coded and controlled manually or automatically from a central control point. Relays at any point in the distribution system receive the coded output and accept or reject it according to conditions. The relays can be used, for example, to start or stop ventilating systems.

Communications may be a very important feature in a modern building. In addition to regular telephone service, internal telephones may be installed; systems for transmitting and printing messages, loudspeaker installations, fire alarms, and others are all in regular use and involve various control systems.

Requirements and Purchase of Instruments

There can obviously be no generalization about the person or department responsible for determining instrument requirements or for their purchase, in this field. So much depends on the type of building, who operates or occupies it, who is the owner, and so on. A commercial or financial organization would probably rely on the advice of consultants or contractors for the specification of instruments, whereas an organization normally involved in engineering might well have considerable direct control of the design and construction of the building, including specification and purchase of instruments. In the case of an educational establishment, the advice of the engineering department or faculty might be obtained.

Service and Maintenance

There are probably few instances at present of instrument maintenance being done entirely by a resident technician or engineering staff, though some preventive maintenance is carried out by building operators' own staff. Other service is often purchased as required or supplied by contract. Spare parts are carried in some instances, but by no means to the same extent as is customary for industrial installations.

Nearly all instruments used are standard lines and are purchased outright. However, with the use of advanced techniques, for example in the field of communication, some specialized instruments may be called for, and there is the possibility of renting, rather than buying, expensive installations such as those used in data processing applications.

Instrument Costs

Comprehensive data on the cost of instruments used in buildings, as discussed here, are not available. However, for a large modern office building the capital investment in instruments may be in the $100,000 to $500,000 range.

DISCUSSION *(Continued from page 91)*

than 100 meters. In the author's opinion this scattering was not serious for heads as low as 80 meters but in drafting this section of the code it was agreed to name 100 meters as the minimum for which the method was fully applicable.

A question raised by Mr. Johnson and Mr. Lester regarding certain features of the method is quite pertinent. Mr. Johnson draws attention to the fact that "accurate measurement of temperature per se is not the problem but accurate measurement of the average temperature rise." Mr. Lester refers to the difficulty introduced in measurement if a tailrace is common to several machines and also to heat exchange with the exterior. Careful and extensive investigations were made of the location of temperature probes at the draft tube exit section and it was found that precise location of the probes was not essential as the thorough mixing of the flow as it passed through the turbine resulted in uniform temperature throughout the measuring section. The correct measurement of *average* temperature rise is thus assured. The author is of the opinion that precisely correct placing of the probes is not as important as correct placing of current meters at a measuring section or correct location of injection valves in the salt velocity method.

The temperature probes at entrance are so placed as to measure conditions at entrance to the scroll case, and at the exit in the draft tube of the unit under test. The tailrace common to several units is seldom, if ever, a problem and the distance between entrance and exit probes so short that interchange of heat with the exterior is insignificant.

One of the difficult problems with which a test engineer must often contend in field tests of turbines is the difference between the rated head and the actual head during a test. Mr. Aeberli's analysis of this problem is a valuable contribution with which the author fully agrees. Variation in headwater and tailwater levels can seldom be controlled and the engineer frequently has difficulty in determining accurately the probable performance of the turbine at the rated head from tests made at a test head differing appreciably from the rated head. For Francis turbines of low specific speed corrections are not too difficult but as the specific speed increases, and particularly for propellor and Kaplan turbines the derived results for rated head become more and more suspect. It then becomes necessary to make adjustments according to the indications of model tests if these are available.

Some years ago the author had an opportunity to make a test of a large turbine at speeds varying from ten per cent above to ten per cent below the rated speed. From these results correction for variation of the test head from the rated head were readily made. The specific speed of the unit was 40 and the indications are that the variations follow the three halves rule over a fairly wide range. In another case for a fixed blade propellor runner a Gibson test was made at a head close to the rated head of 52 feet and, later, Power-gate and index tests were made at various heads down to about 36 feet. It was found that the exponent of the variation of the power with head was quite different from 1.5 and also that it varied with the gate opening. Tests of a model in its proper setting would be of great value in such cases.

A discussion of practice regarding the use of step-up formulas suggested by Mr. Aeberli, it is considered, would be too voluminous to permit its inclusion in this discussion. Much valuable information regarding this subject is contained in the three publications referred to by Mr. Johnson in his discussion.

Mr. Johnson's criticism that the fundamental bases of the Allen Salt Velocity Method have never been rigorously established and his comments regarding errors resulting from incorrect measurement of time of passage of the salt solution cannot be contradicted. Notwithstanding comparisons of the results from this method with measurements by other methods indicate that a high degree of accuracy is secured.

No comments are made regarding Mr. Logan Kerr's discussion but the author takes this opportunity to express appreciation for the kindly remarks from one with whom he has had happy associations in various fields for over thirty-five years.

Canadian Developments

Sixty years ago railways were the arteries of economic development. Spanning the country, they brought gold out of the North, grain and fruit from the West and wood products from the East. In 1959, however, transportation needs go far beyond the conveyance of products and resources. Manufactured goods must be delivered—men must be able to travel in every direction for business—and tourists, demanding a route for their travels, have become a recognizable factor in the national economy.

CHANGES in the volume, nature and variety of byway traffic call for a more complex and flexible system. The speed with which science transforms our daily situation also reminds us that routes must be built today not only to fill our present needs but to meet future trends.

Population increase is outstripped by the rise in number of vehicles on the road and, as innumerable separate units go their independent ways without the need of a despatcher, the highway demonstrates its enormous advantage in flexibility. At the same time a significant economic inducement is offered by a transportation system in which roads of all classes can be freely interconnected.

Highway engineering has been revolutionized and associations have been organized to set standards in roadbuilding practices as well as materials. But the funds for road construction are in the hands of the governments. The Canadian Good Roads Association has had a direct influence upon government road construction policy. For example, only 5% of government-contracted road work is done by government employees as a result of the CGRA's well-substantiated contention that the nation's roadbuilding should be carried out through competitive tenders. Wise planning and budgeting is the CGRA's current preoccupation.

The Economics of Roadbuilding

C. W. Gilchrist, managing director of the Canadian Good Roads Association, claims that if Canadian prosperity continues, $15 billion will be spent on roads and streets in the next 10 years. He predicts that motor vehicle travel will increase from 1958's 36.8 billion miles to approximately 77.5 billion miles in 1968. And yet, he says, there is no integrated plan for Canadian highway development.

Highway economics is worth considering. Accidents, lost time, and vehicle maintenance and operation costs are an expenditure exacted by old roads. Mr. Gilchrist, speaking to the Eastern Canada Association of Highway Officials in New Brunswick recently, pointed out that for each mile of road carrying 2,000 vehicles a day, a paved surface would result in a saving in vehicle operation costs alone of $14,600 a year over a gravel surface. The waste in two or three years, then, would equal the cost of a pavement that would last for 25 years! Mr. Gilchrist emphasized the importance of needs studies in every highway department to bring the level of services up to a desirable standard. Ontario has already done this and Manitoba and Saskatchewan have studies in progress.

Timber being transported by rail for processing.

Highway Engineering

The science of highway engineering has become so highly diversified as to include planning, location, design, construction, maintenance, traffic operations and research. Planning involves study of population and traffic growth and logical prediction of how industrial and residential areas will increase. Vacation habits in any given area must be accounted for as well as congestion factors of other kinds. The requirements and standards of each specific highway improvement and its integration in the overall system thus become the planner's first concern.

Location engineers must select the best, most economical route to serve both the travelling public and commercial drivers. They take the standards deduced by the planning engineer and apply them to the geographical situation. Whereas they once had to cover mile upon mile of prospective road site by foot, photogrammetry now sketches the proposed areas for them. Correlation of aerial photographs with topographical maps results in quite a detailed knowledge of the area under study.

The investigation-design engineer is the next link in the road-building chain; with a knowledge of soil mechanics and construction, he is able to take the plan and profile prepared by the planning engineer and proceed with borings and soundings of the terrain. Design of the highway will depend upon the kind of soil he finds and the amount of bedrock, swamp, and quarry that he discovers, as well as design criteria and the functional demands of the roadway to be built.

AASHO Road Test

The American Association of State Highway Officials is conducting a $23 million road test at Ottawa, Illinois to determine the behaviour of both rigid and flexible pavements of known thickness under moving loads of known magnitude and frequency. Canadian highway technologists await results of the test with considerable interest because the findings should effect not only road and street pavement design, but road operations, design techniques, construction procedures and maintenance practices of all highway departments. In fact, the influence may well be felt by truck manufacturers — in any revision of legal road limits and allowable tire pressures which come as a result of the test. Road administrators and legislators may revise methods of taxing road users and allocating road and street costs. CGRA has taken an active interest in the test since 1955 and employs a resident engineer to assist the committee on the project and report back to the CGRA on developments.

Report on Muskeg Research

A study of road design and performance over muskeg has been published by I. C. MacFarlane of the National Research Council and Alex Rutka of the Ontario Department of Highways. Their interest focuses on Northern Ontario where an expanded construction program must take into consideration quite extensive muskeg regions. They have investigated forty-four different muskeg regions in the area from North Bay to Kenora and Rainy River and studied roads over muskeg for surface condition and performance in comparison with adjacent roads over mineral soil. The men found correlations between: vane shear strength and depth, water content of the peat and depth, vane shear strength and water content, specific gravity of the peat and water content, and acidity and carbon content of peat.

Standards and Traffic Safety

Road Schools for Technical Assistance

According to Alex J. Graham, road superintendent and engineer, County of Carleton, Ottawa, technical assistance to municipalities comes from The Department of Highways, materials and machinery suppliers, consulting engineers and interested organizations. About 86% of the road mileage in Ontario is under municipal authority. Large sums are spent each year and in most cases the work is directed by non-technical staffs. Mr. Graham, speaking at the recent CGRA convention in Vancouver, stated that the value of consultants as a source of technical assistance had not yet been realized. He pointed out, however, that the roads schools held by several of the materials and machinery suppliers, by the Provincial Highway Department, and now by the Ontario Good Roads Association, may fill the municipalities' immediate need for technical assistance. The students they draw are mostly non-technical foremen and members of municipal operating staffs. These are the men who are responsible for large expenditures on the majority of Ontario's roads.

New D.H.O. Claims Committee

The Ontario Government has established a "permanent, independent committee, empowered with authority to consider and settle claims between the Ontario Department of Highways and contractors working on Department contracts." Under the new system, if the contractor is not satisfied with the ruling of the chief engineer, he may appeal to the Special Claims Committee. The contractor is also allowed, if he fails to agree with the ruling of the Committee, to litigate the claim in the Ontario courts. Three distinguished engineers have been chosen by the Ontario Government as members of the Special Claims Committee. They are: Gordon Mitchell, formerly director of seaway operations, chairman; F. Stuart Lazier, and William B. Crombie, formerly of Ontario Hydro.

Uniform Road Markings

A new manual of Uniform Traffic Control Devices for Canada has just been published. The CGRA and the Canadian Section of the Institute of Traffic Engineers have collaborated over the last three years to produce this manual which recommends uniform standards for traffic signs, signals and pavement markings. Before long people driving from coast-to-coast will find that roadway signs and signals convey the same message on intercity highways, city streets and township roads. Some new signs will also appear on Canadian roads. Turn prohibition signs, a black arrow on a green background, will be initiated. Trans-Canada signs will be green and white; school signs, blue and white; civil defence signs, blue and gold.

Accident Study in Alberta

Results of raising the speed limit on four-lane highways in Alberta have been compiled for the months of July and August. Whereas the legal limit for daytime driving was 55 m.p.h., it is now 65 m.p.h. On all but two of eight highway stretches the number of accidents was appreciably decreased. These two highways are undivided. According to Gordon E. Taylor, Minister of Highways, the divided four-lane highways greatly reduce the chances for head-on collisions. Head-on collisions have been completely eliminated to date on the four-lane divided highways in Alberta.

Canadian Highway Safety Council

Ira G. Needles, Chairman of the Board, B.F. Goodrich Canada Ltd., has been elected 1959-60 Chairman of the Canadian Highway Safety Council. He succeeds Geo. B. Kenney of Montreal, associate manager of the Phoenix of Hartford Insurance Companies and director of the All Canada Insurance Federation.

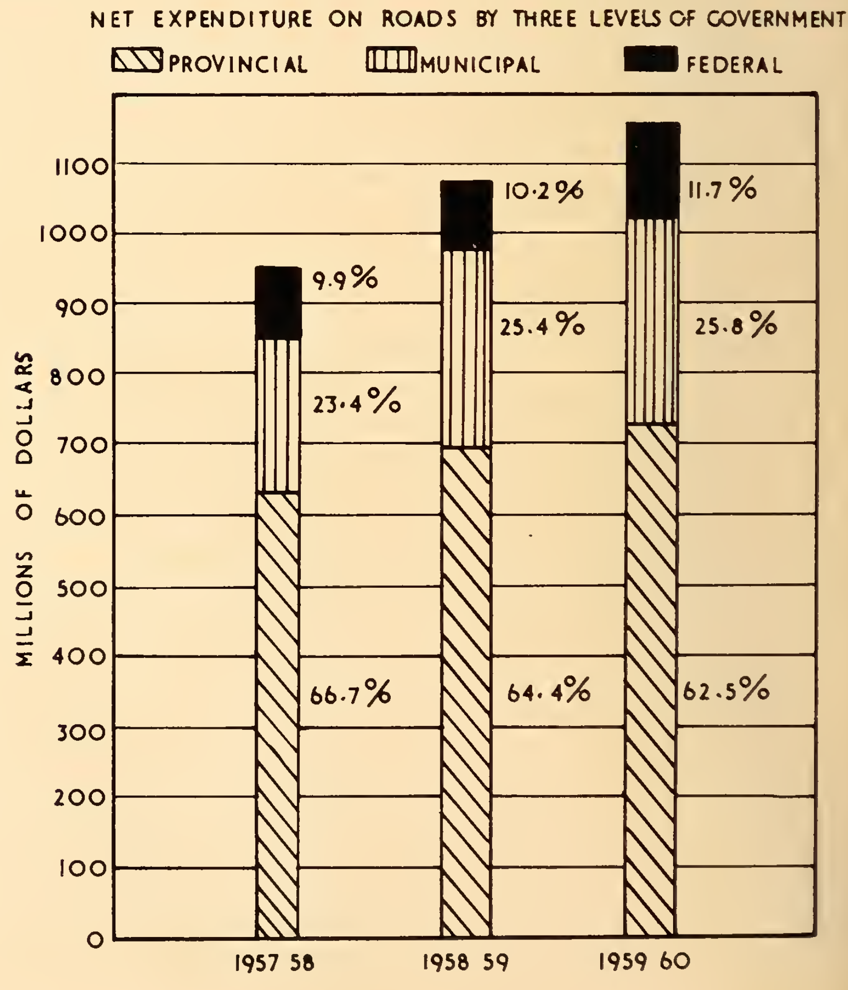
Also elected were Superintendent J. R. W. Bordeleau of RCMP headquarters, Ottawa, as CHSC secretary, and George H. Jackson, vice-president of the Ford Motor Co. of Canada Ltd., as treasurer.

Elections took place at the annual meeting of the Council's general committee in Montreal, Oct. 5. The meeting also elected to change the name of the organization, substituting "Council" for "Conference". It is now the Canadian Highway Safety *Council*.

Provincial Programs and Budgets

Canada spent more for roads in 1959 than ever before. The Canadian Good Roads Association publication "Highway Finance 1959" states that Canadian Governments at three levels will have spent $1,157.2 million on highways by March 31, 1960, the end of this fiscal year. This figure represents an increase of $79.5 million, or 6.9%, over the $1,077.7 spent last year. The increase, however, is at a slightly lower rate than that of the post-war years.

Canadians spent $3 per capita



more on highways this year than last and became some of the highest spenders for roads in the world.

The CGRA booklet shows that the federal government has increased its participation in road-building considerably, while the provincial governments have occupied themselves less with financing roads.

The Roads-to-Resources contributions rose from $6 million to $9 million, but the Trans-Canada Highway support declined by almost $2 million. Greater federal funds are being made available for road projects in the Northwest Territories and the Yukon.

Ontario led in 1959 with a roads expenditure of $268.6 million, an increase of $241.6 million over last year. The next highest spender was Quebec with a budget of $147 million. Last year she spent $177.5 million. British Columbia has also decreased her roads expenditure from last year's $75.8 million to $74.2 million. Manitoba's budget for 1959 shows the greatest increase — from $35.6 million to $65 million.

Cost of Saskatchewan's Ten-Year Program Up

In 1955, when Saskatchewan launched a 10-year program for construction of 12,000 miles of gravelled secondary highways, the costs were estimated at $50 million. Now, due to increases in construction costs, the project is expected to run to $66 million. The provincial government and municipal governments are sharing costs on a 60-40 basis.

Northern Roads

The Department of Northern Affairs and National Resources works in close co-operation with the Department of Public Works and the Department of Mines and Technical Surveys. A committee formed of the three, as well as keeping informed of transportation trends and Northern developments, must constantly predict the consequences of their road projects — what minerals may be reached and what kind of market prospects they may have. The progressive development of these northern roads, in fact, depends to a very great extent upon how much mineral wealth they lead to and how easily they allow the riches to be gotten out to processing centres.

"The development roads," says George M. Carty, chief administrative officer, Department of Northern Affairs and National Resources, "are intended to open new areas to intensive exploration and subsequent investment, and their construction and design reflects this purpose. Since funds are limited, the object is to construct roads initially to meet only essential traffic requirements. However, the basic location and engineering provides for improvements as the traffic warrants."

The oil and gas potential in the north lands which has come to light in the last few years may be the touchstone to extensive northern roadbuilding. Already a road is being constructed from Flat Creek (near Dawson) in the Yukon to serve oil developments on Eagle Plain. This is Canada's most northerly road. Mr. Carty predicts that if oil and gas discoveries proceed as authorities have reason to hope they will, some day before long Canada will need an overland connection with the Arctic Coast. More than half a million acres in the North were added in October, 1959, alone to the eighty-six and a half million already under gas and oil exploration.

Northern Roads for Defence

T. N. Carter, a past-president of the Canadian Construction Association, has said: ". . . within the next decade people will be able to drive from Edmonton to Inuvik on the Arctic Ocean . . . This would have sounded like pure fiction not so long ago but a northern road network is absolutely essential for the development of our country and for the defence of this hemisphere."

Budgets for Northern Roads

Five federal-provincial agreements are now before the federal cabinet for approval and, if passed, could authorize upwards of $20 million in roadbuilding for the year 1960. If these agreements are passed, more than $100 million will be allotted to roads in the North over the next six or seven years. Since the Northern Roads Program concerns the Yukon and the Northwest Territories, appropriations for it are separate from the $20 million set aside for federal-provincial agreements. These two territories alone will probably have a budget of about $10 million.

Saskatchewan Roads Progressing

Rock, rough hilly terrain, muskeg, perma-frost — everything is there to discourage the roads engineers of Saskatchewan's north country. Despite the hardships they have reached Mile 30 on the LaRange-Uranium City road, according to W. A. Sheard, department construction engineer. The road has been cleared to Churchill but for an eight-mile gap. Piers and abutments for the Churchill River bridge have been completed and steel work will be completed by the end of winter.

CGRA Holds "Parliament of Roads"

September 22 to 25 were busy days in Vancouver, as 1,200 delegates poured into the city for the Canadian Good Roads Association's 40th "Parliament on Roads." Hon. J. T. Douglas, Minister of Highways and Transportation, Saskatchewan, described the CGRA as a "hard-working partnership of governments and business in a field that directly serves everyone." He stressed the need for planning and budgeting wisely on all three levels of government to keep up with the nation's highway demands. He also encouraged federal assistance to provinces, noting that Saskatchewan's experience in the construction of the Trans-Canada Highway had proved to him how well federal aid to highways could work to the benefit of both governments and need in no way interfere with provincial jurisdiction (as provided for in the British America Act).

Coast-to-Coast Survey

As a prelude to numerous technical sessions on highway and transportation problems, the CGRA presented a Canada-wide roads roundup and came up with the following information:

British Columbia: working on a 55-mile freeway network to be built in the Vancouver metropolitan area. To cost $465 million. To be completed by 1976.

Alberta: constructing access roads from main highways to 22 towns and making construction of by-passes in, through, and around major cities an important budget item.

Saskatchewan: constructing multi-lane facilities, interchanges and urban road simplification.

Manitoba: establishing a planning section through the Highways Division of the Automotive Safety Foundation to analyze road problems and set roads standards.

Ontario: working towards a completely integrated system of roads. Trans-Canada Highway network in Ontario to be completed by 1960.

(Continued on page 140)

INTERNATIONAL NEWS

A discussion of international highways almost leads one these days to ask: Just where do they end? The reply might well be: At the moon.

Dr. Wernher Von Braun, director of the U.S. Development Operations Division of the Army Ballistic Missile Agency, was recently asked, "When will construction start on the moon—ten, twenty or thirty years?" This was before the Russians' rocket pierced the moon. He replied:

"I could very clearly envision that within another 15 or 20 years, we will have quite some extensive construction work going on on the moon for certain projects. I mean there will be some road building going on."

International Highways

How ever far away such development may be on the surface of the moon, there is much activity across the Earth today to link its continents together. A highway is being pushed across the great Asian desert; another is biting into the tundra and rock of Alaska. There are endeavours to construct a tunnel under the English Channel, and the Inter American Highway is being stretched from Honduras to Costa Rica.

Trans-continental Highway for Asia

United Nations officials have agreed to convert 7,000 miles of ancient caravan routes into a modern continental highway system for Asia. Only by careful study of ancient records will experts be able to re-discover much of the old caravan route and to plot a new course thereupon for the modern Iran-to-Viet Nam highway.

The highway subcommittee of the United Nations Economic Commission for the Far East has approved the project. It divides Asia into three highway regions — Viet Nam, Cambodia, Laos, Thailand, Malaya, and Burma in the first; West Burma, East Pakistan, India, Ceylon, and Nepal, the second; and West Pakistan, Afghanistan and Iran, the third.

Just as these caravan routes were the great trade links of the Ancient World (the "silk road" ran from China through North India to Delhi and on to the Black Sea), authorities have reason to hope that new highway system will revitalize the Asian countries' economies.

To Link Alaska Panhandle with B.C.

Alaska Commissioner of Public Works, Richard Downing, has announced that work will begin on the first 20-mile stretch of the only highway between Petersburg in Alaska's Panhandle and British Columbia's Stewart-Cassiar Route now under construction.

However, B.C.'s first concern has been a corridor road through the Panhandle to the sea as an outlet for future northern industries. Governor William A. Egan of Alaska, has now assured B.C. authorities that he is ready to select land for a corridor and port facilities which, if leased to Canada, would be subject to Canadian laws.

Alaska Highway Paving Shelved

The Alaska Highway will not be paved for at least another two years. The U.S. government has recently shelved a plan to share the $132 million paving costs with Canada.

At the same time Premier W. A. C. Bennett of British Columbia has formally withdrawn his province's offer to the federal government to take over the cost of maintenance on the 600 miles of Alaska Highway in B.C. in return for a tract in the Northwest Territories. According to Defence Minister Pearkes, the federal government is anxious to get rid of maintenance and paving responsibilities on this section of the highway. The wartime project now has less significance from a defence standpoint, but increased civilian traffic to Alaska and the Yukon necessitates a considerable annual expenditure for maintenance.

Inter American Highway

Not to be confused with the Pan American Highway, the Inter American Highway is currently being extended from El Espino in Honduras to Nicaragua's capital, Managua. With the completion of the $6½ million highway, Nicaraguans will have nearly 200 miles of all-weather road. Considered in the context of a climate which thoroughly drenches the land six months of the year, the Inter American Highway is an impressive achievement.

Though ox carts are still much in use in Nicaragua, car and truck traffic is constantly mounting. Nicaragua's rubber crop is but one factor which necessitates highway development and will also make it prosper. The asphalt highway is financed two-thirds by the U.S., one-third by the Republic of Nicaragua.

Tunnel Under the English Channel

Once plans are approved, construction of a twin rail tunnel under the English Channel would take less than seven years. So says the president of The Channel Tunnel Company which was formed several years ago to study the project. Plans have been prepared which would make the building of such a tunnel feasible. Presumably the tunnel would be for a modified railway car which would carry both goods and people. Authorities do not think that automobile traffic would be feasible both because it would be difficult to provide space for breakdowns and because most people would not be able to bear the mental and nervous strain of driving thirty miles through an artificially lit, narrow tunnel.

The Tancarville Bridge

In July of this year a 4,626 ft. suspension bridge was inaugurated at Tancarville on the Seine. Authorized and financed by appropriations from the Special Highway Development Fund and by bonds against the earnings from the bridge tolls, the project, begun in 1937, was held up by the war. Construction got underway again in 1955.

Nineteen thousand metric tons of steel, 117,715 cu. yds. of concrete, and 209,275 cu. yds. of earthwork have gone into making this bridge. Half a century's realization that some large-scale means of conveyance was needed near the Seine's estuary and as many years of small ferries and other insufficient devices have spurred this noteworthy achievement. It is predicted that traffic tolls will soon pay for the bridge. People crossing the estuary of the Seine from the right bank save 60 miles on their way to the West by using the Tancarville Bridge and 43½ miles when going toward the Southwest. The bridge also promises a wholly new economic potential to the rich agricultural regions of Normandy which it unites.

Metropolitan Expressways

Philadelphia's Schuylkill Expressway

Highway engineers have had to cope with some singular problems in order to run an interstate highway between Philadelphia's 30th Street Station and the immediately bordering Schuylkill River. They have met them by constructing an expressway along the lower level of the east side of the station with ramps to the upper plaza overhead. They have extended the plaza to the riverline, laid out a double rotary system around the station, and run a new four-lane boulevard across the river, straight into the heart of the city, to relieve congestion from the station itself.

The highway comprises two 26 ft. wide roadways separated by a 4 ft. raised dividers low enough to be passed over in emergencies. A 25 ft. deep layer of muck and uncompressed silt along the line of the road also had to be calculated. Soils engineers have estimated that settlement will be at a rate of 1 in. in every five years for every additional foot of fill placed on the area. Fill depth varies from 1 to 15 ft. and therefore fill had to be excluded from design considerations. Instead, steel piles were driven through the muck to the underlying mica schist.

Oklahoma City Expressway

A two-mile elevated expressway will cut through Oklahoma City four blocks south of the downtown business district. Six 12 ft. roadways, an 8 ft. divider, and 6 ft. shoulders are its components. The new expressway will link all principal routes in and out of the city and will have only four entrance and exit ramps. The major span is over the main line and yard tracks of the Santa Fe Railway.

Boston's Rapid Transit

Boston's Metropolitan Transit Authority took over an abandoned railroad line on the west side of the city and converted it into a $7 million rapid transit service in mid-1958. Whereas the railroad had carried an average of 2,200 passengers a day, the rapid transit this September was taking more than 25,000 people back and forth from work.

U.S. Cuts Roads Budgets

The U.S. government has released figures on state and interstate apportionments for the fiscal year 1961. The federal allotment falls a good deal short of the amount authorized by law. The $2.7 billion apportionments to states, in fact, is $463,000 less than the obligations made by the states in 1959.

The interstate apportionment for 1961 is $1.8 billion which is $2 million less than the amount authorized by law. Federal aid has been falling off generally since the beginning of the year in all fields of construction.

Auto Design

German automotive engineers are asking themselves if there isn't some replacement for the conventional piston engine in automobiles. Designers are looking for an engine which could do without a gear. The gas turbine would appear to be the most likely prospect, though the high volume of exhaust which it gives off is prohibitive in these days of heavy traffic. In its favour are two factors—its size is one third that of the piston engine and it demands a simpler gear.

International Congress

The 8th International Automobile Technical Congress will be held at The Hague from May 9-13, 1960. The subjects of study include: gasturbines, transmissions, lubrication, combustion, fuels, chassis, gearbox, suspension gears, tires, brakes, body, equipment, aerodynamics, styling and safety. The congress will be carried on in three languages simultaneously, French, English and German.

Highway Engineering

Rubber In Roads

Rubberized bitumen is being used in many parts of the world where heavy-duty surfaces are required. The Queensland district of Australia has more than a thousand miles of such road; New Zealand's Northern Highway is another example; in the Far East an emulsion incorporating latex has been used quite extensively in roads. Both the U.S. and England have been testing rubber as a roads material for a decade.

In an attempt to find an improved form of natural rubber, researchers have come up with natural rubber latex (with and without special additives) and various forms of rubber powder.

Road Roughness Indicators

The Swiss Federal Institute is trying out a new road roughness indicator, the CT-444. The indicator, attached to the back of a truck, is used to determine the surface profile of a pavement, highway, air strip, or street. This equipment is used both to find spots where new surfacing is necessary and to obtain a permanent record so that a re-checking of the same pavement at given intervals can point up areas where preventive maintenance is necessary.

Salt Stabilization

The State of Ohio has completed 681 miles of salt-treated roads in the last five years. Adoption of salt as a stabilizing agent by the Ohio highway department is the outgrowth of experimental work undertaken in 1955 by the state's highway maintenance division to cut down upkeep costs on secondary roads. These farm-to-market roads were the most expensive to maintain of Ohio's 18,000 miles of highway.

Earth Resistivity Interpretation

The Assistant Director of the Testing Laboratory Division, Michigan

State Highway Department, Howard E. Barnes, has written an article on earth resistivity tests for sand and gravel prospecting. The author maintains that engineers have depended too long on a little magic black box. He contends that an accurate interpretation can be made from a set of field data. He discusses the difference between reconnaissance survey and a comprehensive survey, but his focus is on the limitations of resistivity instruments.

American Air Car

An American company began production of a 300 h.p., four-passenger Air Car in November. The car travels on a cushion of low pressure, low velocity air at a height of from six to twelve inches and can travel equally well over land, water, swamps and mud. This Model 2500 will travel at speeds up to 60 m.p.h. Before long both an Air Bus and an Air Truck will be manufactured as well.

Saucer-shaped Skimmer

The British National Research Development Corporation is currently sponsoring work on the SRN 1 Hovercraft. The saucer-shaped craft skims the surface of land and sea supported by a 12-in. cushion of air. The experimental prototype has made the Channel trip from Calais to Dover and is now being tested on land. It holds a considerable potential as a freight and passenger carrier, both as a ferry on the channel and as a carrier over rough terrain.

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New French Engineering Company To Advise Petroleum Industries

A new company which will offer consulting engineering services to the petroleum and petrochemical industries has recently been formed in Paris. It is called "Etude et Realization de Projets Industriels (Planning and Undertaking of Industrial Projects).

The new company, headed by an American citizen and professional engineer in the State of New York, Mr. J. G. Devys, will provide market studies and economic evaluations; assistance in technical research; process development, appraisal and design; foreign and domestic contracts in view of common market undertakings; and negotiations for carrying out major industrial projects in Western Europe and underdeveloped countries.

Their address will be: 26 rue de la Pepiniere, Paris 8.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

Noranda Copper and Brass Limited will be the recepient of the E.I.C. Certificate of Advertising Merit for the "best" advertisement in the September issue.

This four-colour advertisement, which appears on page 33, is a dramatic presentation of molten alloy being poured. It is headed "QUALITY THAT FLOWS INTO YOUR PRODUCTS", and the copy covers control of quality and performance. In part, the copy states "every production step is not only rigidly controlled but carefully integrated to assure quality brass mill products that help improve your products, reduce your costs, increase your profits". Emphasis is laid on the fact that Noranda brass mill products are made by Canadians from Canadian ore.

The fifty members who were asked to serve on the jury to select the "best" advertisement in the issue were asked to make their selection from the viewpoints of ACCURACY – INFORMATION and ATTRACTION.

The certificate will be presented to Mr. R. C. DeVilliers, Advertising Manager of the Company and a duplicate will be presented to Hazard Advertising Agency who prepared and placed the advertisement.

NORANDA COPPER AND BRASS LIMITED WINNING ADVERTISEMENT

The advertisement reproduced above was judged to be the "best" from the viewpoints of ACCURACY–INFORMATION and ATTRACTION by the fifty readers who were asked to review the advertisements in the September issue.
The advertisement is printed on good grade coated stock, is extremely attractive and the copy is factual and concise.

Month to Month

Ten Branches Participate in Banff Conference

Below left Mr. and Mrs. Clarence B. Antenbring and Mrs. John B. Striowski stop for a moment in the midst of Banff activity.

Below Professor John Mantle of the University of Saskatchewan, coordinator of the technical sessions at Banff, talks with Dr. John Convey, director of the Department of Mines & Technical Surveys, Ottawa.

Members and their wives from Calgary, Saskatchewan, Central British Columbia, Edmonton, Lethbridge, Vancouver, Vancouver Island, Winnipeg, Kootenay, and Yukon enjoyed three lively days of meetings and good weather at the Western Zone Technical Conference in Banff from October 1 to 3.

Prefaced by the Irrigation Forum on Thursday, October 1, the conference got formally underway with 9 o'clock registration Friday morning followed by the first technical session. The day's program included a general luncheon (with a special luncheon for the Professional Development Seminar), technical sessions, cocktails, a banquet, a soiree review and dance.

On Saturday, October 3, technical sessions filled the morning and were followed by luncheon and golf at the Banff Springs Course.

The ladies were feted on Friday with a tea and bridge parties at Timber Line Hotel and on Saturday they were taken on a grand tour of the surrounding vacationland.

Technical sessions included discussion of irrigation methods, power developments, economics of oil mining, muskeg, construction projects, Northern affairs, land survey, hydro survey, and soils study.

Ottawa Conference Marks 50th Anniversary of Ottawa Branch

The Chateau Laurier bustled with engineers on October 15 and 16 as E.I.C. members from Ottawa and the neighboring branches gathered for the Ottawa Regional Technical Conference. This was the 50th anniversary year for the Ottawa branch and the first year that a regional conference had ever been held in the national capital.

Fourteen papers on subjects as diverse as nuclear research, new power sources, sewage treatment and mining were presented in the course of the two days. The talk given at Thursday's luncheon by Mr. Winnett Boyd of Montreal on nuclear engineering and its bearing on the future development of Canada created considerable interest at the conference and in the press.

Friday's luncheon address was given by Dr. John Convey of the Department of Mines and Technical Surveys. His words on Mining and Metallurgy in the Ottawa Valley formed an appropriate introduction to an afternoon of mining topics.

Mr. R. F. Legget opened the Friday morning session on Ottawa Valley projects with an interesting history of engineering projects of an earlier era in the valley. The conference also featured suitable displays set up by the Atomic Energy Commission and the National Capital Commission.

The conference wound up with a ballroom dinner dance at which members were honoured with an address by the president of the Institute, Mr. J. J. Hanna.

The Engineers' Wives Association planned a full program for the ladies which included a special tour on Thursday afternoon and a coffee party on Friday morning.

McMaster University Inaugurates New Engineering Building

Dr. K. F. Tupper, M.E.I.C., officially opened the new Engineering Building at McMaster University on October 23 with the hope that in it "students will acquire habits of industry—a willingness to work, to concentrate on one thing at a time, to get things done . . . and to read, not as computing machines storing information to give it out upon demand, but critically, using their own judgment."

Following the opening of the Engineering Building, an Engineers Buffet Supper was held. The Autumn Convocation took place that evening.

Honorary Membership to James Alfred Vance

An honorary membership, the highest tribute paid by the Engineering Institute of Canada, was conferred upon James Alfred Vance of Woodstock by President J. J. Hanna at a recent meeting of the London Branch. The council selected five prominent engineers this year to be recipients of honorary memberships, but at the time of the presentation at the 1959 Annual General Meeting Mr. Vance was abroad attending the Tenth Anniversary of NATO as a Canadian delegate.

For many years Mr. Vance was a member of the Woodstock Board of Trade, its president and also a director of the Canadian Chamber of Commerce. Since 1955 Mr. Vance has been an active member of the Ontario Water Resources Commission.

As councillor for the London Branch, vice-president in the Ontario zone, and president of the Institute in 1950, Mr. Vance has served the Institute long and well. In 1953 he was awarded the Sir John Kennedy Medal of the Institute for outstanding merit in the profession.

(Continued on page 135)

Honorary degrees were presented to four members of The Engineering Institute of Canada at the convocation of the University of Western Ontario on October 29. They are (left to right): Henry Gaudefroy, dean of Ecole Polytechnique; Richard Lancaster Hearn, chairman of Ontario Hydro; James Alfred Vance, proprietor-engineer of the James A. Vance Company; and Kenneth Franklin Tupper, president of Ewbank & Partners (Canada) Ltd., Toronto.

James Alfred Vance (right) receives a certificate of honorary membership, the highest honour bestowed by The Engineering Institute of Canada, from President J. J. Hanna.

University Registration

The Institute's tabulation of this year's university engineering enrolment in Canada will be found on the following pages of this issue. This information has been obtained direct from the registrars, and is now an annual Journal service to its readers.

The main highlights of this year's situation, as disclosed by the E.I.C. survey, are the following:

a. The total enrolment in Canadian engineering courses now stands at 14,475 which is down very slightly this year by 77 students.

b. The incoming freshman class is 4150 strong, representing a decrease of 9% as compared with 1958. The drop over the last two years is now 20%.

c. The estimated number of 1960 graduates, making no allowance for wastage during the year, is 2241. This will be a 6½% increase in terms of the 1959 figure, forecast a year ago.

d. New colleges giving recognized engineering courses are still being added to the list. On this occasion we welcome the addition of St. Joseph's University to our survey.

Readers will be able to make further detailed observations by study of the tables. However, if any questions should arise, E. I. C. Headquarters will gladly try to answer them on request.

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Engineering and Business Administration	Forest Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Total
Memorial	1st	42	....	....	....	....	....	....	....	....	....	....	....	....	42
	2nd	41	....	....	....	....	....	....	....	....	....	....	....	....	41
	3rd	38	....	....	....	....	....	....	....	....	....	....	....	....	38
Total		121	....	....	....	....	....	....	....	....	....	....	....	....	121
Dalhousie	1st	72	....	....	....	....	....	....	....	....	....	....	....	13	85
	2nd	67	....	....	....	....	....	....	....	....	....	....	....	6	73
	3rd	29	....	....	....	....	....	....	....	....	....	....	....	8	37
	4th	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	5th	....	....	....	....	....	....	....	....	....	....	....	....	3	3
Total		168	....	....	....	....	....	....	....	....	....	....	....	30	198
St. Mary's	1st	46	....	....	....	....	....	....	....	....	....	....	....	....	46
	2nd	34	....	....	....	....	....	....	....	....	....	....	....	....	34
	3rd	26	....	....	....	....	....	....	....	....	....	....	....	....	26
Total		106	....	....	....	....	....	....	....	....	....	....	....	....	106
St. Francis Xavier	1st	99	....	....	....	....	....	....	....	....	....	....	....	....	99
	2nd	96	....	....	....	....	....	....	....	....	....	....	....	....	96
	3rd	67	....	....	....	....	....	....	....	....	....	....	....	....	67
Total		262	....	....	....	....	....	....	....	....	....	....	....	....	262
N.S. Technical College	4th	....	....	....	20	76	52	....	....	....	34	6	3	....	191
	5th	....	....	....	13	40	45	....	....	....	23	3	4	....	128
Total		....	....	....	33	116	97	....	....	....	57	9	7	....	319
Acadia	1st	51	....	....	....	....	....	....	....	....	....	....	....	....	51
	2nd	32	....	....	....	....	....	....	....	....	....	....	....	....	32
	3rd	41	....	....	....	....	....	....	....	....	....	....	....	....	41
Total		124	....	....	....	....	....	....	....	....	....	....	....	....	124
Mount Allison	1st	71	....	....	....	....	....	....	....	....	....	....	....	....	71
	2nd	72	....	....	....	....	....	....	....	....	....	....	....	....	72
	3rd	47	....	....	....	....	....	....	....	....	....	....	....	....	47
Total		190	....	....	....	....	....	....	....	....	....	....	....	....	190
New Brunswick	1st	....	....	....	2	52	41	....	....	....	29	....	17	....	141
	2nd	....	....	....	2	40	37	....	....	....	32	....	12	....	123
	3rd	....	....	....	2	49	40	....	....	....	24	....	8	....	123
	4th	....	....	....	....	62	34	....	....	....	25	....	....	....	121
	5th	....	....	....	....	52	24	....	....	....	27	....	....	....	103
Total		....	....	....	6	255	176	....	....	....	137	....	37	....	611
St. Joseph's	1st	44	....	....	....	....	....	....	....	....	....	....	....	....	44
	2nd	18	....	....	....	....	....	....	....	....	....	....	....	....	18
	3rd	10	....	....	....	....	....	....	....	....	....	....	....	....	10
Total		72	....	....	....	....	....	....	....	....	....	....	....	....	72
Laval	1st	169	....	....	....	....	....	....	....	....	....	....	....	....	169
	2nd	244	....	....	....	....	....	....	....	....	....	....	....	....	244
	3rd	....	....	....	7	65	24	....	....	3	19	1	6	11	136
	4th	....	....	....	4	56	29	....	....	3	17	9	5	6	129
	5th	....	....	....	15	42	14	....	....	1	15	4	....	5	96
Total		413	....	....	26	163	67	....	....	7	51	14	11	22	774
Ecole Polytechnique	1st	268	....	....	....	....	....	....	....	....	....	....	....	....	268
	2nd	327	....	....	....	....	....	....	....	....	....	....	....	....	327
	3rd	273	....	....	....	....	....	....	....	....	....	....	....	....	273
	4th	....	....	....	7	97	52	....	....	6	34	7	8	21	232
	5th	....	....	....	14	66	33	....	....	....	33	7	7	8	168
Total		868	....	....	21	163	85	....	....	6	67	14	15	29	1,268

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Engineering and Business Administration	Forest Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Total
McGill	1st	232	....	....	....	....	....	....	....	....	....	....	....	....	232
	2nd	252	....	....	....	....	....	....	....	....	....	....	....	....	252
	3rd	....	....	....	28	53	102	....	....	....	41	8	2	21	255
	4th	....	....	....	20	78	102	....	....	....	65	9	7	10	291
	5th	....	....	....	28	65	54	....	....	....	55	7	3	11	223
Total........		484	....	....	76	196	258	....	....	....	161	24	12	42	1,253
Sir George Williams	1st	93	....	....	....	....	....	....	....	....	....	....	....	....	93
	2nd	37	....	....	....	....	....	....	....	....	....	....	....	....	37
Total............		130	....	....	....	....	....	....	....	....	....	....	....	....	130
Sherbrooke	1st	50	....	....	....	....	....	....	....	....	....	....	....	....	50
	2nd	52	....	....	....	....	....	....	....	....	....	....	....	....	52
	3rd	45	....	....	....	....	....	....	....	....	....	....	....	....	45
	4th	....	....	....	....	18	11	....	....	....	3	....	....	....	32
	5th	....	....	....	....	13	7	....	....	....	6	....	....	....	26
Total............		147	....	....	....	31	18	....	....	....	9	....	....	....	205
Ottawa	1st	75	....	....	7	18	12	....	....	....	....	....	4	....	116
	2nd	30	....	....	14	13	17	....	....	....	....	....	2	....	76
	3rd]	....	....	....	5	11	16	....	....	....	....	....	....	....	32
	4th	....	....	....	5	....	9	....	....	....	....	....	....	....	14
	5th	....	....	....	6	....	5	....	....	....	....	....	....	....	11
Total............		105	....	....	37	42	59	....	....	....	....	....	6	....	249
Carleton	1st	34	....	....	....	....	....	....	....	....	....	....	....	....	34
	2nd	30	....	....	....	....	....	....	....	....	....	....	....	....	30
	3rd	17	....	....	....	....	....	....	....	....	....	....	....	....	17
Total............		81	....	....	....	....	....	....	....	....	....	....	....	....	81
Queen's	1st	238	....	....	....	....	....	....	....	....	....	....	....	....	238
	2nd	....	....	....	42	56	37	....	....	16	62	8	15	30	266
	3rd	....	....	....	48	36	46	....	....	12	34	9	10	28	223
	4th	....	....	....	36	34	43	....	....	10	48	11	7	15	204
Total............		238	....	....	126	126	126	....	....	38	144	28	32	73	931
Toronto	1st	....	....	....	80	76	88	25	....	18	75	15	6	119	502
	2nd	....	....	....	62	69	72	41	....	11	61	9	13	125	463
	3rd	....	....	....	54	72	79	31	....	12	81	16	14	75	434
	4th	....	....	....	46	104	97	37	....	25	80	12	20	73	494
Total............		....	....	....	242	321	336	134	....	66	297	52	53	392	1,893
McMaster	1st	64	....	....	....	....	....	....	....	....	....	....	....	....	64
	2nd	44	....	....	....	....	....	....	....	....	....	....	....	....	44
	3rd	30	....	....	....	....	....	....	....	....	....	....	....	....	30
Total............		138	....	....	....	....	....	....	....	....	....	....	....	....	138
Ontario Agricultural College*	3rd	....	....	....	....	17	....	....	....	....	11	....	....	....	28
	4th	....	....	....	....	3	....	....	....	....	12	....	....	....	15
Total............		....	....	....	....	20	....	....	....	....	23	....	....	....	43
Waterloo College**	1st	126	....	....	....	....	....	....	....	....	....	....	....	....	126
	2nd	271	....	....	....	....	....	....	....	....	....	....	....	....	271
	3rd	....	....	....	28	47	33	....	....	....	39	....	....	28	175
Total............		397	....	....	28	47	33	....	....	....	39	....	....	28	572
Western Ontario	1st	96	....	....	....	....	....	....	....	....	....	....	....	....	96
	2nd	39	....	....	....	....	....	....	....	....	....	....	....	....	39
	3rd	....	....	....	4	10	9	....	....	....	7	....	....	....	30
	4th	....	....	....	2	5	10	....	....	....	3	....	....	....	20
Total........		135	....		6	15	19	....	....	....	10				185

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Engineering and Business Administration	Forest Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Total
Assumption	1st	55	....	....	....	....	....	....	....	....	....	....	....	....	55
	2nd	....	....	....	5	20	10	....	....	....	5	....	....	2	42
	3rd	....	....	....	6	7	9	....	....	....	4	....	....	....	26
Total		55	....	....	11	27	19	....	....	....	9	....	....	2	123
Sudbury	1st	16	....	....	....	....	....	....	....	....	....	....	....	....	16
Total		16	....	....	....	....	....	....	....	....	....	....	....	....	16
Manitoba	1st	216	....	....	....	....	....	....	....	....	....	....	....	....	216
	2nd	185	....	....	....	....	....	....	....	3	....	....	....	5	193
	3rd	....	....	....	....	63	50	....	....	3	46	....	....	6	168
	4th	....	....	....	....	48	36	....	....	3	44	....	....	3	134
Total		401	....	....	....	111	86	....	....	9	90	....	....	14	711
Saskatchewan	1st	328	....	....	....	....	....	....	....	....	....	....	....	....	328
	2nd	273	....	....	14	....	....	....	....	....	....	....	....	....	287
	3rd	....	19	1	19	77	36	....	....	17	53	....	....	22	244
	4th	....	6	11	26	66	39	....	....	10	44	....	....	11	213
Total		601	25	12	59	143	75	....	....	27	97	....	....	33	1,072
Alberta	1st	330	....	....	....	....	....	....	....	....	....	....	....	....	330
	2nd	....	....	11	50	112	129	....	....	1	38	4	2	....	347
	3rd	....	....	18	38	79	77	....	....	....	45	8	7	12	284
	4th	....	....	17	42	71	49	....	....	....	22	1	4	9	215
Total		330	....	46	130	262	255	....	....	1	105	13	13	21	1,176
British Columbia	1st	361	....	....	....	....	....	....	....	....	....	....	....	....	361
	2nd	249	....	....	....	....	....	....	....	....	....	....	....	....	249
	3rd	....	....	....	15	39	71	....	....	11	56	9	3	25	229
	4th	....	....	....	16	38	57	....	1	7	38	12	8	26	203
Total		610	....	....	31	77	128	....	1	18	94	21	11	51	1,042
Canadian Services Colleges															
Royal Military College (Kingston)	1st	68	....	....	....	....	....	....	....	....	....	....	....	....	68
	2nd	40	....	....	....	....	....	....	....	....	....	....	....	....	40
	3rd	....	....	....	8	30	25	....	....	....	24	....	....	10	97
	4th	....	....	....	19	27	30	....	....	....	17	....	....	3	96
Total		108	....	....	27	57	55	....	....	....	41	....	....	13	301
Royal Roads	1st	91	....	....	....	....	....	....	....	....	....	....	....	....	91
	2nd	7	....	....	4	16	21	....	....	....	12	....	....	....	60
Total		98	....	....	4	16	21	....	....	....	12	....	....	....	151
College Militaire Royal de St.-Jean	1st	90	....	....	....	....	....	....	....	....	....	....	....	....	90
	2nd	68	....	....	....	....	....	....	....	....	....	....	....	....	68
Total		158	....	....	....	....	....	....	....	....	....	....	....	....	158
Grand Total		6,556	25	58	863	2,188	1,913	134	1	172	1,443	175	197	750	14,475
Prospective 1960 Graduates		...	6	28	244	644	513	37	1	56	438	57	53	164	2,241

*Students in Agricultural Engineering who will proceed to their final year in Mechanical or Civil Engineering at the University of Toronto on completion of their studies at Guelph.

**The figures shown for the University of Waterloo are valid only to the end of December, 1959. This is because course intakes are on the "quarter system" and some of these students will be moving on to higher courses in January 1960 and again in April 1960.

74th

E.I.C.

ANNUAL GENERAL

AND

TECHNICAL MEETING

1960

Royal Alexandra Hotel

WINNIPEG - MANITOBA

MAY 25-26-27

Personals

John Bertram Sterling, HON. M.E.I.C.

L. Austin Wright, M.E.I.C.

Lawrence C. Sentance, M.E.I.C.

Nikolajs Strauss, M.E.I.C.

The two new companies, Beaco Limited and Canengco Limited, Montreal, have brought together a number of prominent E.I.C. members to offer independent consulting services in Canada and abroad. **John Bertram Sterling,** Hon. M.E.I.C. (Queen's '11) is to act as director and chairman of the board of Beaco Limited, while **L. Austin Wright,** M.E.I.C., a past general secretary of E.I.C. (Toronto '11) is the director and chairman of the board of Canengco Limited. **Robert F. McCune,** M.E.I.C., has been named director and president of the two companies; **Andrew T. Wilson,** M.E.I.C. (Queen's University, Belfast '46), director and vice-president, Beaco; **Donald C. MacCallum,** M.E.I.C. (McGill '38), director and executive vice-president, Canengco and director, Beaco; **Alexander G. Moore,** M.E.I.C. Nova Scotia '25), director, Beaco; **Thomas A. Monti,** M.E.I.C. (Ecole Polytechnique '41), director, Beaco; and **H. John Racey,** M.E.I.C. (Queen's '28), executive vice-president, Cia. Canadiense Internacional De Ingeneria, a Beaco subsidiary.

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.

H. William Tate, M.E.I.C. (Toronto '10) is the new chairman of the board of De Leuw, Cather & Company of Canada, Limited, Consulting Professional Engineers, Toronto. **Leslie W. Pillar,** M.E.I.C. (King's '25) has been appointed president.

G. J. Currie, M.E.I.C. (Nova Scotia '31) has been made assistant chief engineer of Nova Scotia Light and Power Company, Limited and subsidiary companies.

Lawrence C. Sentance, M.E.I.C., (Saskatchewan '35) is the new manager of the Canadian Westinghouse Company's atomic energy division.

Robert H. Hobner, M.E.I.C. (Manitoba '35) has been appointed project engineer with the Northern construction division of the Department of Public Works' building construction branch in Ottawa.

Henry W. E. Rosenthal, M.E.I.C. (Darmstadt '37) has been made mechanical engineer in charge of production with L'Hoir Inc. at Levis, Quebec.

S. M. Breuning, M.E.I.C. (Stuttgart '49) has left the University of Alberta for a post at Michigan State University, Lansing, Mich.

Nikolajs Strauss, M.E.I.C. (Latvia '41) has been appointed by the Minister of Public Works, Ottawa, to the post of highways materials engineer with the development engineering branch of the public works department in Banff.

J. A. MacLean, M.E.I.C. is the new manager, central district of Associated Electrical Industries (Canada) Limited. **K. R. Brown,** M.E.I.C. (London Polytech. '44) has been appointed manager of their Pacific district.

(Continued on page 112)

OBITUARIES

Ralph Clinton Purser, M.E.I.C., for many years a member of the administrative staff of the Topographical Survey of Canada, died on September 9, at the age of 73.

Mr. Purser was born at Windsor, Ontario, in 1886. He graduated from the School of Practical Science, University of Toronto, in 1907 and obtained a commission as dominion land surveyor in 1910. He became a commissioned Ontario land surveyor in 1921.

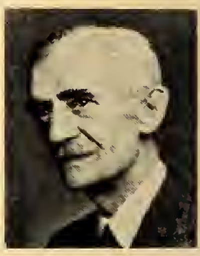
In 1909 Mr. Purser worked in southwestern Alberta as assistant on D.L.S. surveys. The following year he returned to Windsor, Ontario, to work on the staff of J. J. Newman, Dominion and Ontario Land Surveyors, as civil engineer.

From 1911 to 1932 Mr. Purser was chief-of-party and then surveys engineer for the Topographical Surveys Branch of the Department of the Interior, later the Topographical Survey of Canada, in the Canadian West. He was in the administration of this organization from 1924 to 1932.

Instrumental in founding *The Canadian Surveyor,* a magazine published by the Canadian Institute of Surveying and Photogrammetry, Mr. Purser acted as its honorary editor from its inception in 1922 until 1928.

Upon his retirement from the Dominion Government Service in 1932, Mr. Purser took up free-lance writing and acted as Ottawa correspondent for a number of papers. A considerable part of his writing dealt with technical subjects and was published in national trade magazines.

Ralph Clinton Purser, M.E.I.C.



Dr. Edward P. Fetherstonhaugh, M.E.I.C.

Tom Herbert Chapman, M.E.I.C., lost his life in a sailing accident near North Bay, Ontario, June 15.

Born in Toronto, March 20, 1917, Mr. Chapman attended the University of Toronto and received his B.Sc. in mechanical engineering in 1949.

In 1957 Mr. Chapman, working with Milne Laidlaw Associates, consulting engineers to the lumber industry, travelled to Russia and did contract work for the Russian government at Archangel.

Prior to this Mr. Chapman had worked on layout and design conveyor equipment for Linkbelt Limited in 1949-50. From 1950 to 1954 he was an engine salesman for Geo. W. Crothers, Ltd., engineering and selling diesel power units for power sawmills, power shovels and electrical generators.

The Great Northern Woods Co. Ltd.'s projected North Bay plant became his concern in 1954, when he was sent up they by D. W. Milne to develop the first plant in Canada for finger-jointing and edge-glueing white pine.

A squadron leader in the RCAF, Mr. Chapman was awarded the Distinguished Flying Cross for his services.

Edward Phillips Fetherstonhaugh, HON. M.E.I.C., a past president of the Engieering Institute of Canada, died in Winnipeg on October 19th, in his 81st year.

Dr. Fetherstonhaugh was born in Montreal and graduated from McGill University in 1899. After five years of engineering practice in Ottawa and Montreal he returned to McGill, this time as a lecturer in electrical engineering, a position he held until 1907. He then moved to Winnipeg, where in 1909 he was appointed professor of electrical engineering at the University of Manitoba.

During the First World War Dr. Fetherstonhaugh served in France with the Royal Corps of Canadian Engineers and was awarded the Military Cross.

With the return of peace he resumed his teaching at the University of Manitoba, where he became the first dean of the faculty of engineering and architecture in 1921.

Dean Fetherstonhaugh was for a number of years a member of the National Research Council. He had joined the Engineering Institute of Canada as a student in 1899, subsequently becoming a member of the Winnipeg Branch executive, then chairman, then councillor until in 1945 he was elected to the presidency of the Institute. He was the recipient of the Julian C. Smith Medal for that year — the year of his retirement — and in the same year McGill conferred on him an honorary degree of Doctor of Science.

Guy Montague Wynn, M.E.I.C., a member of the Institute since 1915, died in Montreal on October 2, 1959.

Mr. Wynn was born and educated in Niagara Falls, Ontario. After attending Toronto University he joined the Ontario Power Company at Niagara Falls as engineer-in-charge of surveys for construction.

When Mr. Wynn took up a position with T. Pringle & Son, Montreal, 1905, he launched out on a 47-year career with that company. At the time of his retirement in 1951 he was executive head of the firm. Among countless other projects, Mr. Wynn was in charge of the design and construction of the Canadair Ltd. plant, which at the time was considered the largest of its kind in the Commonwealth.

James Alexander Walker, M.E.I.C., died in Vancouver on September 22nd at the age of 72.

As engineer-secretary of the Vancouver Town Planning Commission from 1921 to 1952, Ontario-born Mr. Walker was affectionately known to the people of his adopted city as "Sandy Walker".

He was largely instrumental in drafting Vancouver's zoning by-law, and also created town plans for New Westminster, West Vancouver and North Vancouver city and district. Among the civic structures he helped to develop and build were the new Granville Bridge, Burrard Bridge, and the underground Canadian Pacific Railway tunnel in downtown Vancouver.

Mr. Walker was educated at the University of Toronto and served in the Canadian Army during the First World War. He became a Life Member of the Institute in 1953.

Oliver Tiffany Macklem, M.E.I.C., for thirty years a member of the department of civil engineering at Royal Military College, died on May 1, 1959.

Born in 1883, Mr. Macklem attended R.M.C. and McGill University, where he earned a B.Sc. degree in 1908. He began teaching at R.M.C. in 1909 as an instructor of civil engineering and remained there until his retirement in 1938 but for a period of military service in World War I. In 1920 he was made an associate professor and in 1933 he became a full professor and head of the civil engineering department.

Mr. Macklem came out of retirement for a short time during World War II to teach civil engineering at Queen's University.

William Laird Smith, S.E.I.C., was the victim of an automobile accident on April 19, 1959. He was 23 years old.

William attended Manor Public & High School in Manor, Saskatchewan, and went on to earn his degree in petroleum engineering at the University of Saskatchewan in 1958. In 1959, working as a laboratory instructor in petroleum, he received his diploma in commeıce.

At the time of his death, William was working for British American Oil at Stattler, Alberta.

TRANSACTIONS

OF

THE

E.I.C.

VOL. 3 NO. 3

DECEMBER 1959

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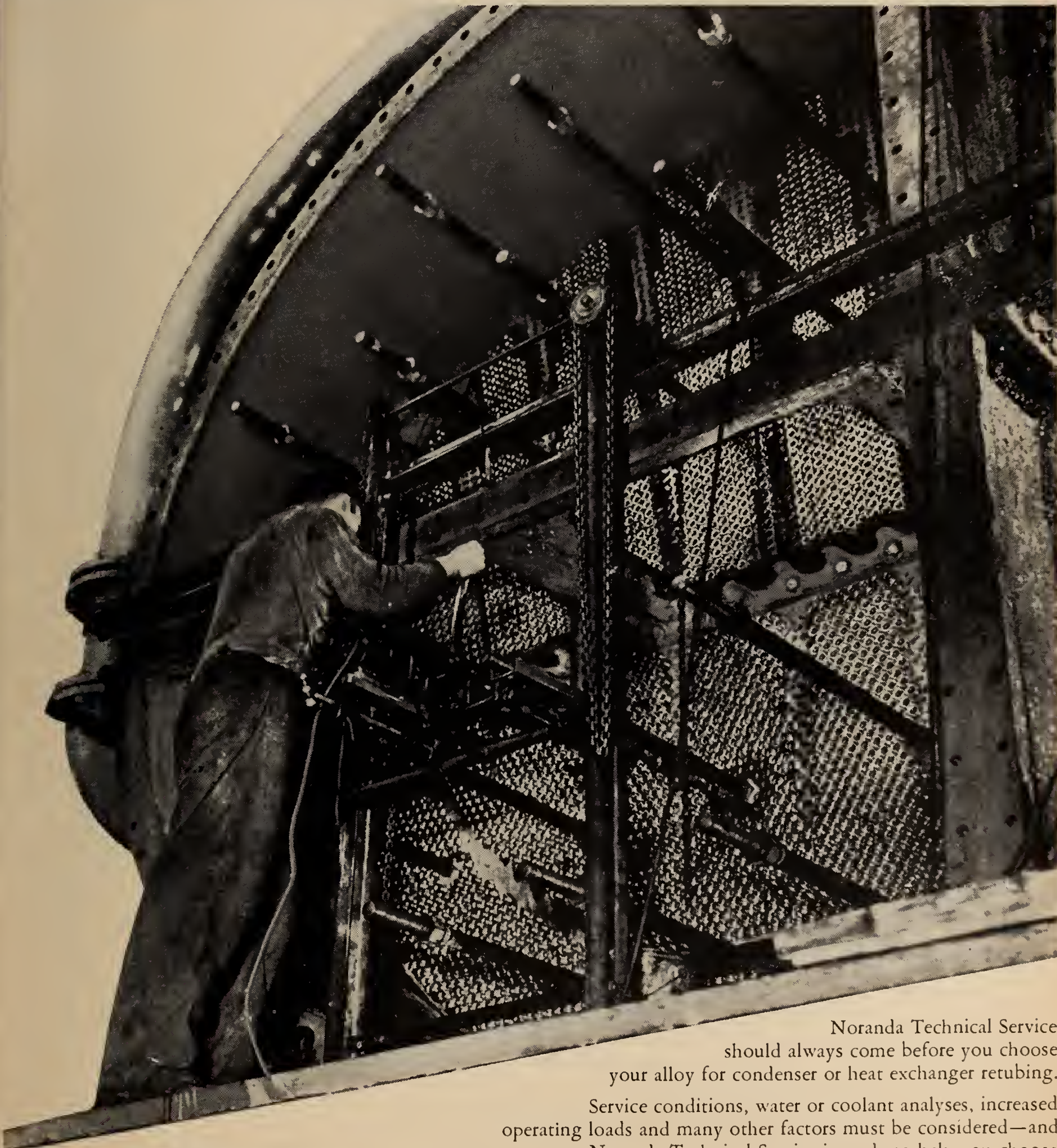

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NEWS OF THE BRANCHES

ASSUMPTION UNIVERSITY OF WINDSOR

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

President Hanna and J. Hance Legere, director of technical services, spoke to one hundred student engineers on October 23rd. Mr. Hanna stressed the importance of assessing the meaning of engineering as a profession before entering into practice, and suggested to the students that they study the code of ethics in their respective provinces. Mr. Legere spoke briefly on the nature and benefits of membership in E.I.C.

BORDER CITIES

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

We were honoured to have as guests at our annual dinner dance October 23rd our president, Mr. Hanna, and Mr. J. Hance Legere. A reception preceded a smorgasbord dinner at the Essex Golf and Country Club. In a short speech, Mr. Hanna gave the branch several stimulating suggestions for direction. He also talked on Canada's wealth of resources and warned against squandering them for short-term gain.

CAPE BRETON

H. M. Aspinall, M.E.I.C., *Correspondent*

The wives of members and affiliated members of E.I.C. were guests of Mrs. C. M. Anson at an afternoon tea on October 23rd. Greeting the many guests were Mrs. Anson and Mrs. Clifford Murray, president of the Cape Breton Engineers Wives Association.

On October 30th E.I.C. members held a dance followed by a buffet lunch.

CHALK RIVER

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

Mr. A. G. Muirhead, general manager of Gillies Bros. and Co. Ltd., sketched the historical development of lumbering in the Ottawa Valley at the September 30th meeting. Lumbering began with the felling of timber to provide agricultural land and to obtain potash and has progressed to the production of sawn, kiln-dried lumber and of pulp. Talking about means of protecting forest stands from fire, Mr. Muirhead pointed out that more timber is destroyed each year by fire than by logging. He suggested that in many cases natural regrowth is preferable to planting.

EDMONTON

I. G. Finlay, M.E.I.C., *Correspondent*

D. B. Menzies, M.E.I.C., Commissioner, City of Edmonton, speaking to branch members on September 28th, outlined several important problems which in his opinion would be solved by amalgamating the City of Edmonton and several fringe municipalities and towns.

On October 28th V. R. Currie and D. Dewar of the Department of Transport spoke on Edmonton's new airport. Mr. Currie explained its construction features, while Mr. Dewar talked about navigational problems.

HAMILTON

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

A plant tour of the Saint Lawrence Cement Company in Clarkson, Ontario gave members, their sons, and McMaster engineering students a chance to inspect modern dust collecting and materials handling equipment.

On November 26th a progress report on the NRU atomic reactor at Chalk River was presented to members at the Hamilton Armories.

HURONIA

L. Morgante, JR.E.I.C., *Correspondent*

Elected to office at the September meeting were: chairman, S. R. Walkinshaw; vice chairman, A. H. Pangman; directors, F. Alport, E. L. Cavana, R. MacKay, D. M. Harris, W. A. Plant, and C. A. Fry; secretary-treasurer, L. Morgante.

LETHBRIDGE

R. J. Knight, JR.E.I.C., *Correspondent*

The director of planning at Old Man River District Planning Commission, S. J. Clarke, was guest speaker at the October 24th meeting. Outlining the position of a professional planner in today's municipal population explosion, Mr. Clarke explained that the value of city planning is often misunderstood. He pointed out that one has only to view the existing results of poor planning to realize that efficiently coordinated communities do not just happen.

MONTREAL, JUNIOR SECTION

Bernard Michel, JR.E.I.C., *Correspondent*

Twenty-five members participated in the annual golf tournament on September 9th at the St. John Golf Club. A dinner followed.

Registration for the Professional Development Seminar was held on October 8th. Two classes of participants have been formed as a result of high enthusiasm among the junior members.

NIAGARA

E. C. Little, M.E.I.C., *Correspondent*

The annual engineers' dinner and dance were held at Prudhomme's Garden Centre on September 25th for some 225 couples.

On October 28th our president, J. J. Hanna, talked to members about work at headquarters. Technical papers, political legislation affecting engineers, and innumerable subjects such as the Borden Report and how problems which headquarters deals with.

NIPISSING AND UPPER OTTAWA

R. D. Christie, JR.E.I.C.,
Correspondent

Members heard J. F. Chantler, a former chairman of the branch and currently general mills superintendent, Kipawa Mill, Canadian International Paper Co., Temiskaming, Que., talk on Communications and Industrial Supervision in late September.

Speaking on employer-employee relations, Mr. Chantler suggested: "If the subordinate knew he could have understanding without reproach, and disagreement without retaliation, then there would be true communication."

R. S. McLennan of North Bay was appointed vice-chairman and J. Warburton, executive committee member.

ONTARIO AGRICULTURAL COLLEGE

Leeroy L. Gordon, S.E.I.C.,
Correspondent

"Engineering Projects with the United Nations" was the subject of an impromptu talk on November 3rd by H. Kitching, formerly with F.A.O. in Rome and the Colombo Plan in Pakistan. Mr. Kitching outlined the organization of the United Nations and went on to explain F.A.O's place within the U.N. His illustrations of F.A.O. projects were taken from power machinery work, for that has been his own field since 1953. He talked in some detail about assignments he planned in various parts of Africa, South America and Southwest Asia and showed coloured slides of the projects.

SAGUENAY

E. E. Paine, JR.E.I.C., *Correspondent*

P. S. Subramanian and A. Subramanian spoke to a group of members of E.I.C. and the Saguenay Chapter of the Corporation of Professional Engineers of Quebec on October 20th. As senior engineers in the Madras Electricity Authority, the two men spoke on "The Electrification of Madras." They have been concerned with the installation and operation of Colombo Plan hydro-electric plants.

SAINT JOHN

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

New Brunswick's Attorney-General, Hon. R. G. L. Fairweather, QC, was speaker at a dinner meeting at the Riverside Golf and Country Club on October 26th. He described the duties and responsibilities of his office to the assembled group of engineers and their wives.

ST. MAURICE VALLEY

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

Fall activities commenced on October 22nd when 40 members with their wives attended a dinner meeting at the Cascade Inn in Shawinigan. Chairman W. A. Pangborn presided and the gathering was addressed by Dr. Gerald Kaine on "The Implications of Recent Advances in Medicine." He covered the development of antibiotics, quinotherapeutic agents, Cortisone ACTH, Insulin and anticoagulants and their use in treating viral diseases, arthritis, diabetes and thrombosis. Recent developments in cancer research were also traced.

SASKATOON

W. A. Friebel, M.E.I.C.,
Correspondent

Cyril N. Hoyler, manager of technical relations at the David Sarnoff Research Centre of R.C.A. Laboratories, Princeton, N.J., spoke to a large gathering on October 19th describing some outstanding advancements in the electronics of solids. He reported that a number of new solid materials have been developed within which electron action can be precisely controlled to achieve a variety of useful effects. Electroluminescent materials, according to Mr. Hoyler, will be the next step in industrial lighting.

We were shocked and grieved to learn that two days after his visit to the Saskatoon branch, on October 21st, Mr. Hoyler was killed in an automobile accident at Moosomin, Sask.

SAULT STE. MARIE

R. L. Wimperis, JR.E.I.C., *Correspondent*

A hydro film entitled "From Dream to Reality" describing the Saint Lawrence Seaway in the area of Long Sault Rapids west of Cornwall was shown at the October 16th meeting. This is one of the better films we have seen and goes into such aspects as the many diversions, coffer dams, which eventually resulted in the elimination of the Long Sault Rapids; the building of power dams; flooding of large areas along the river; and moving of several towns.

One of our non-resident members, Mr. G. Cameron of the Hydro Red Rock Falls project, paid us a visit accompanied by several hydro engineers. It is rare that we see non-resident members because of their wide dispersement.

TORONTO

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

A Symposium on Engineering Ethics was held on October 29th, with the following participating: Dr. G. R. Lord, head of the department of mechanical engineering, University of Toronto; Dr. G. B. Langford, head, department of geological science, Univ. of Toronto; Mr. J. F. McLaren, James F. MacLaren Associates; and Mr. Joseph Sedgewick, Q.C.

Meetings of the Joint Area Committee (Civil), the Electrical Section, and the Power Section have also been held. Members of the latter heard a paper on the Border Dam Power Plant prepared by Ewbank & Partners (Canada) Ltd. on November 11th.

UNIVERSITY OF NEW BRUNSWICK

Ardean Stairs, S.E.I.C., *Correspondent*

Professor I. M. Beattie, M.E.I.C., head of the civil engineering department at the University addressed student members October 5th on "The Philosophy of Engineering". Chairmen of various committees were elected and the meeting wound up with refreshments. Plans are being made for Engineering Week, January 23-29, 1960.

Senior engineering students went on a tour of the Hartland Bridge and the Beechwood Power Development on September 20th.

VANCOUVER

C. H. White, M.E.I.C., *Correspondent*

The B.C. Electric Small Auditorium was the meeting place for a talk on "Modern Developments in Concrete Technology" October 20th. Raymond J. Schutz, technical director of the Sika Chemical Corporation, Passaic, N.J., was the speaker.

Mr. Schutz stressed the variety of possibilities offered by modern concrete. Unit weights vary from 23 lbs./cu. ft. up to 350 lbs./cu. ft. and compressive strength ranges from 100 lbs./sq. in. up to 10,000 lbs./sq. in. The low-weight and strength concretes, he explained, are lightweight concrete fills, while the high strength concretes are used in pre-stressed work. The high unit-weight concretes are being put into shielding for atomic energy projects.

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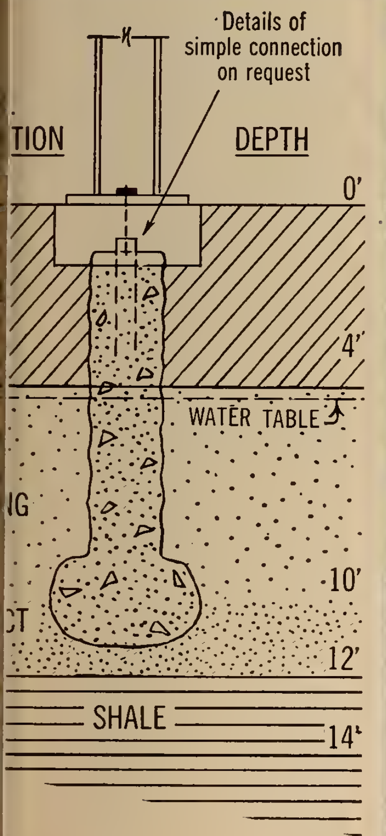

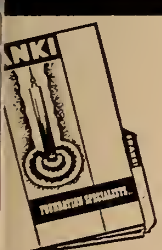

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FUNDAMENTALS OF BOILER HOUSE TECHNIQUE

Intended to help bridge the gap between the practical and theoretical consideration of problems concerned with boiler house technique, this text covers types of boilers; water treatment; steam; fuels; flue gas testing; atmospheric pollution; combustion; solid, liquid and gaseous fuels; and boiler house efficiency and testing. (P. D. Dehnel. London, Hutchinson, 1959. 25/-.)

CRUSHING AND GRINDING; A BIBLIOGRAPHY

The first part of this volume contains a series of short reviews of crushing and grinding in connection with ceramics, cement, minerals, chemicals, etc., and of fire and explosion hazards in crushing and grinding operations.

The 2800 annotated references in the bibliography are classified under the general headings of: fundamental aspects; crushing and grinding practice; equipment; coarse reduction; fine reduction; non-mechanical methods; materials; methods of particle size and surface area determination; classification; dust and fire hazards. Each section is further subdivided. There are name and subject indices. (W. H. Bickle, comp. London, H.M.S.O., 1958. 425p., 35/-.)

FEDERATION INTERNATIONALE DE LA PRECONTRAINTE, 3rd CONGRESS, 1958

The increased use of prestressed concrete is reflected in the sixty-two papers presented at this Third Congress, held in Berlin in May 1958.

The speakers came from all over the world, including Eastern Europe, and the papers are written in English, French, German or Spanish. The first session was concerned with developments in design methods. The second discussed progress in prestressing technique as applied on the site, with special reference to grouting, anchorages, reduction of friction, and safety precautions. The last group of papers is concerned with progress in the manufacture of factory-made precast, prestressed, concrete units and in their use and assembly on the site.

A second volume, not yet published, will contain the discussions. (Ed. by R. P. Andrew. London, Cement and Concrete Assoc., 1958. 766p., $40.00, special price to E.I.C. members $30.00.)

THE AUDIO CYCLOPEDIA

Written in the form of 3400 questions and answers, this reference work covers all phases of audio, including hi-fi and stereo. Among the topics covered in the 26 sections are: basic principles of sound; acoustics; constant speed devices; attenuators; sound mixers; vacuum tubes; transistors and diodes; recording of all types; motion picture projection equipment; loudspeakers; test equipment; stereophonic recording.

The information is easily accessible by means of a 54 page index, there are many useful illustrations and diagrams, and the volume should prove invaluable. (H. M. Tremaine. Indianapolis, Sams, 1959. 1269p., $19.95.)

CITIES IN THE MOTOR AGE

This volume is an attempt to summarize and evaluate a conference held in 1958 which discussed the problems of the rapid urbanization of the United States.

It is a penetrating discussion of city planning, the U.S. national highway programme, suburban versus city life, the role of the railroads, and the impact of the automobile on everyday living. (Wilfred Owen. Toronto, Macmillan, 1959. 176p., $4.50.)

*THE EXPLORATION OF SPACE BY RADIO

Surveys the field of astronomical studies, including the radar techniques for the investigation of various aspects of the solar system, as well as the receiving techniques which are used to study the solar and the galactic and extragalactic radio emissions. Specific aspects discussed include the hydrogen line, scintillation of the radio stars, meteors, the aurora borealis, and the Jodrell Bank radio telescope. (R. H. and A. C. B. Lovell. Toronto, Ryerson, 1957. 207p., $7.00.)

CONCRETE: THE VISION OF A NEW ARCHITECTURE

Dealing with the architectural rather than the technical aspects of reinforced concrete, the purpose of this study is to describe the development of a new building material, and to discuss the efforts of architects to find its most appropriate form.

The first part of the volume deals with the history of concrete as a building material between 1800 and 1914, when it came into general use. The second part considers the work of architects of the nineteenth and twentieth centuries.

The third, and largest, section of the book is devoted to the work and theories of Auguste Perret who was regarded as the leading figure in the field during the first half of this century. Many illustrations of his work are included.

The author, an associate professor of architecture at McGill University, worked for some years in the office of one of Perret's pupils. He believes his study will be of interest to the many structural engineers "who have to collaborate with architects, and find their attitude of mind quite incomprehensible." (Peter Collins. Toronto, British Book Service, 1959. 307p., $12.75.)

*JOINTS AND CRACKS IN CONCRETE

Essentially this is a practical guide to the use of joints in the building of sound structures, although some consideration is given to theoretical aspects. It gives a survey of jointing materials and methods of construction, describes correct and economical jointing techniques, and discusses diagnosis and treatment of faults. With the aid of diagrams and photographs most types of concrete structures in which jointing problems are likely to arise are covered, including buildings, water-retaining structures, pavings, bridges, masonry construction, and concrete pipes. (P. L. Critchell. London, Contractors Record, 1958. 232p., 40/-.)

*INTERNATIONAL COMMITTEE ON ELECTROCHEMICAL THERMODYNAMICS AND KINETICS. NINTH MEETING. PROCEEDINGS

A collection of papers discussing thermodynamical data and potential – pH diagrams, electrochemical definitions, experimental methods in electrochemistry, batteries and accumulators, corrosion and protection against corrosion, electrochemical kinetics, and modern electrochemical methods in analytical chemistry. The papers are written in French, German and English. (Toronto, Butterworth, 1959, 489p., $24.00.)

°GENERAL GALVANIZING: A MANUAL OF GOOD PRACTICE

Combines the results of research work with the practical experience of experts in the British galvanizing industry. The manual covers degreasing and paint removal, pickling, preparation of castings, rinsing and pre-fluxing, dipping, fluxes for wet galvanizing, ash formation and treatment, dross formation and recovery, inspection and testing, and finishing treatments. (Montreal, Consolidated Mining and Smelting Co., 1957. 56p., $3.00.)

°MATHEMATICAL PROGRAMMING AND ELECTRICAL NETWORKS

A new approach to mathematical programming based on an analogy with electrical networks. It is shown that any direct-current electrical network made up of current sources, voltage sources, ideal diodes, and ideal transformers is equivalent to a pair of dual linear programs. A simple algorithm is developed for solving diode-source networks which is applicable to network flow problems including the transportation problems. A procedure for algebraically tracing the breakpoint curve of a diode-source-resistor-transformer network is derived, and it is used to obtain optimal solutions to general linear or quadratic programs. (J. B. Dennis. New York, Wiley, 1959. 186p., $4.50.)

°LABOR MANAGEMENT RELATIONS

Employee-employer relations are discussed from a highly practical point of view. Methods are presented for the solution of the problems involved in this relationship, and new techniques are presented for management administration and policy in both union and non-union operations. The importance of proper labor contract language is stressed as are the effect that emotions have in labor relations, the problems of the union shop, and the effect of "right to work" laws and strikes. (C. Wiedemann. New York, Reinhold, 1959: 142p., $3.75.)

°PARIS SYMPOSIUM ON RADIO ASTRONOMY

A collection of papers reporting the latest advances in radio astronomy. The authors discuss moon reflections, radio emission from Jupiter and other planets, radio emission from the quiet and active sun, radio studies in the discrete radio sources (radio stars), radio evidence on the large scale structure of our own and external galaxies, cosmology, and the mechanisms by which solar and cosmic radio waves are generated. These papers constitute the proceedings of a symposium held in 1958 which was jointly sponsored by the International Astronomical Union and the International Scientific Radio Union. (Ed. by R. N. Bracewell. Stanford, Cal., Stanford University Press, 1959. 612p., $15.00.)

°PROGRAMMING BUSINESS COMPUTERS

Intended for the person involved in day-to-day application of electronic computers to business data processing problems, the book begins with such fundamental concepts as the central concept of the file, flow charting, and the general characteristics of electronic computers. Numerous examples are then given to explain the standard techniques of coding. These examples are written in terms of a hypothetical computer called DATAC which is a compilation of the features of many machines. Also included are such advanced techniques as timing estimates, file organization, automatic coding, and random access storage devices. The authors conclude with a summary of the steps involved in establishing a computer application, and an examination of the accounting and auditing problems associated with electronic data processing. (D. D. McCracken and others. New York, Wiley, 1959. 510p., $10.25.)

°AUTOMATION AND COMPUTING

Following an historical background of automation and of analog and digital calculation, the author discusses the logical design of calculating machines and the application of digital and analog techniques to automatic process control, machine tool control, and assembly. The achievements of computing machines in various fields are assessed, including that of sports and translation, and it is shown that automation can play an important part in office procedure and in strategic and economic planning. (A. D. Booth. Galt, Brett-Macmillan, 1959. 158p., $5.00.)

°THE THEORY AND DESIGN OF MAGNETIC AMPLIFIERS

Practical design techniques are combined with theory in this survey of transductors and magnetic amplifiers. Those aspects discussed include transient and steady-state operation of idealized transductors, self-excited and auto-excited transductors, closed loop control systems, transient and frequency response of transductors, high-speed transductors and magnetic amplifiers, balanced magnetic amplifier circuits, low level amplification and multi-stage amplifiers and magnetic modulators. (E. H. Frost-Smith. London, Chapman and Hall, 1958. 487p., $15.00.)

°HEAT TRANSFER ENGINEERING

A unified approach to heat transfer based on two fundamental concepts: the first law of thermodynamics referred to as energy balance, and the various rate equations. The author discusses basic conduction theory; free convection; forced convection, including heat transfer in compact surfaces and to and from liquid metals; radiation between two or more bodies; and unsteady-state conduction in one, two, and three dimensional systems. Various applications are then considered such as the finned or extended surface, the simple boiler and condenser, and the heat exchanger in its various forms. (H. Schenck, Jr. New York, Prentice-Hall, 1959. 310p., $9.25.)

• MONTH TO MONTH

(Continued from page 105)

Birmingham College Administrators Visit Montreal

Dr. Venables and Dr. Slater, respectively principal and head of the department of Metallurgy at the Birmingham College of Technology in England, were guests of honour at a luncheon given at the University Club, Montreal, on October 16th, by the Institute. The two men were in Montreal for several days visiting Ecole Polytechnique and McGill University. Dr. Venables also spoke to the Montreal branch of E.I.C. on British Engineering Education.

Present at the luncheon were Dean Mordell and Professor Bruce of McGill, Dean Gaudefroy and Professor Vinet of Ecole Polytechnique, A. Deschamps, G. Boissonnault, G. N. Martin, R. S. Eadie and E. C. Luke of the Institute, representing Dr. Page who was unable to attend.

New Canadian Fairs Council

A committee representing national professional, scientific, engineering and educational organizations has recently announced the formation of a Canadian Science Fairs Council to promote the science fair movement.

Boys and girls attending public and private schools are to show exhibits, demonstrations and collections at these fairs which they have prepared outside school hours. This is an effort to extend students' interest in pure and applied science.

Pending appointment of a full-time science fair co-ordinator, the council will have headquarters in the offices of The Chemical Institute of Canada, 18 Rideau Street, Ottawa.

The new Council is supported by E.I.C., The Chemical Institute of Canada, Canadian Education Association, Canadian Teachers' Federation, Canadian Association of Physicists, and various other professional bodies.

The Engineering Index

The critical needs of engineers and scientists for better access to the rapidly mounting volume of engineering and scientific publications are being studied by a Science Information Service under the leadership of the American Science Foundation.

Engineering Index, Inc., is housed in the Engineering Societies Building, 29 W. Thirty-Ninth Street, New York 18. Since 1885 its job has been to index all technical publications.

Subscribers to the Engineering Index receive abstracts in the form of 3" x 5" library cards daily which give a brief review of all scientific articles which come to the Index's attention. Subscribers who do not wish this complete service can signify their particular area of interest and thus receive all pertinent abstracts, in this same 3" x 5" card form, once a week.

International Association for Bridge and Structural Engineering

E.I.C. recently became a corporate member of the International Association of Bridge and Structural Engineers, as approved by Council in October 1958. The association aims to promote international co-operation among engineers, scientists and manufacturers. With frequent publications, and congresses every four years, it endeavours to disperse knowledge, ideas and results of research work in the sphere of bridge and constructional engineering in general. Headquarters are in Germany and transactions are carried on in English, French and German.

Employment Bulletin No. 59-12

EMPLOYMENT SERVICE

SITUATIONS VACANT

CHEMICAL

CHEMICAL ENGINEERS AND CHEMISTS—with up to 5 years' experience required by leading Chemical manufacturing company to work on the development of new processes and products and the improvement of manufacturing techniques. This is an unusual opportunity to join a top team of Canadian engineers and scientists in a rapidly expanding organization. Salary fully commensurate with experience and qualifications. Applications in writing will be treated confidentially. File No. 6829-V.

CHEMICAL ENGINEER for technical sales. Toronto location. Travel in Ontario. This is an opportunity for an experienced man seeking broad and general sales responsibility in an expanding medium sized chemical company, serving paper, textile, paint and varnish industries. Salary open. File No. 6882-V.

ENGINEERING GRADUATE for general all round duties in chemical process plant in Western Canada. Modern home available. All usual fringe benefits. Permanent position. File No. 6896-V.

MECHANICAL ENGINEER

Required by

SASKATCHEWAN RESEARCH COUNCIL

The position will involve applied research in selected projects concerned with the industrial development of the province. The fields of fluid mechanics, thermodynamics, heat transmission and machine design will be involved, i.e. pilot plant designs, development of pneumatic and hydraulic transport, cold weather lubrication etc. 37½ hour week, 3 weeks vacation, sick leave, pension plan, time allowed for University courses. Salary range $6000-$7500 per annum, dependent upon qualifications. Send full particulars to Engineering Division, Saskatchewan Research Council, Saskatoon, Saskatchewan.

CIVIL

GENERAL SUPERINTENDENT REQUIRED. By General Contractor in Eastern Ontario City. This man must have a proven record of performance on building contracts in excess of one million dollars and be capable of directing the work of several job superintendents with the utmost economy. Applicant must be capable of dealing with Architects and Engineers and settling matters with considerable dispatch. Graduation in civil engineering would be preferable but not mandatory. Top salary and good future prospects for the right man. Replies treated confidential. File No. 6837-V.

THE NEW ZEALAND MINISTRY of Works invites applications for the following vacancies on the Permanent Staff. Positions, qualifications desired and salaries offered are as follows: CIVIL ENGINEER: Corporate membership of the Institution of Civil Engineers, London or equivalent qualification, together with sufficient appropriate experience. Commencing salaries up to £1485 per annum. ASSISTANT CIVIL ENGINEERS: A University Degree in Civil Engineering or Graduate Membership of the Institution of Civil Engineers, London with at least five years of practical experience since commencement of pupilage. Commencing salaries £830 up to £1020 per annum. File No. 6881-V.

ENGINEERING PARTNER. Architect in private practice five years desires civil engineering partner. Location South Central Ontario city. File No. 6883-V.

CIVIL ENGINEER with at least 7 years' structural steel and concrete design experience. Must be able to direct design team in Montreal. Should be bilingual and preferably Canadian University Graduate. State salary expected. File No. 6888-V.

CHIEF ENGINEER, Civil or Municipal. Our client, a very well-established and expanding firm of consulting engineers, requires two chief engineers for Prairie branch operations. Under the general direction of the Branch Manager, responsibilities will involve the direction of all branch engineering work, including the supervision of resident engineers, inspectors, and surveyors, generally engaged in the design and installation of municipal facilities. Requirements include an engineering degree and qualifications for professional registration in any one of the Western Provinces. Applicants should have at least several years of relevant experience, preferably in consulting or municipal work. Preferred age range 35-45. Initial salary $600 to $800 as a minimum, with a very good possibility of becoming a member of the firm within a few years. Write in strict confidence, quoting Reference No. 293, and give full details of training, experience, and personal data to: STEVENSON & KELLOGG LTD., Member Association of Consulting Management Engineers Inc., 810 Royal Bank Building, Vancouver 2, B.C. File No. 6889-V.

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, including traffic control facilities. An interest in Community Planning desirable but not essential.

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.

CIVIL ENGINEER required for appointment to the permanent staff of medium sized firm of engineers and contractors doing heavy construction (Mines, Mills, Grain Elevators, Docks and Bridges) and operating primarily in Northwestern Ontario. Applicants to be Professional Engineers with a minimum of five years' experience in appropriate design and or construction. Experience with heavy piled foundations and cofferdams an asset. Personality and ambition essential. Applicants to give full details and salary expected in first communication. File No. 6892-V.

CIVIL ENGINEER young and energetic, with one or two years' construction experience to eventually manage estimating and expediting for firm of General Contractors, Province of Quebec. File No. 6893-V.

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.

THE ENGINEERING JOURNAL

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Volume 42—January To December 1959

AUTHORS

The term "s", below, refers to Supplement to the April 1959 Issue, "Report of Council for 1958"

AUTHORS (*continued*)

SUBJECT

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.

DECEMBER, 1959

ADVERTISING OFFICES

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D. W. Campbell
2050 Mansfield Street, Montreal
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H. A. Mackenzie
4a Bloomsbury Square, London W.C.1, Engl-
Phone: HOLborn 3779

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.